A Developmental Investigation of Core Priming Effects on the Dative Alternation in German-Speaking Monolingual and Bilingual Children and Adults

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22. Oktober 2025, Kaiserslautern

[Alina Kholodova]

Acknowledgements

This work is dedicated to my grandparents, whose unwavering belief in the power of knowledge and personal growth inspired me to pursue a PhD. They always stressed that material wealth holds no true value in defining one's personality. To them, these things were fleeting, inconsequential, and ultimately irrelevant to what truly matters in life. They taught me that it is not what we own, but rather how we think, how we engage with the world, and how we use our knowledge and beliefs to influence and inspire others as well as how we contribute meaningfully to society. This perspective has shaped not only my academic journey but also my approach to life, reminding me that true success comes from the meaningfulness of deep commitment to making a positive impact on the world around us.

Being raised bilingually, I developed a particular fascination for bilingual language acquisition. During my studies in English and German Philology, Prof. Dr. Wolodymir Kuschneryk supervised both of my master's theses with unwavering dedication. I am profoundly thankful for his guidance and our productive collaboration. He not only strengthened my academic and personal development but, most importantly, set the course for my future research on bilingualism. After a several years of pursuing a teaching career, I realized I had reached the limits of my growth in that role, which led to a pivotal moment when Prof. Dr. Shanley Allen offered me the chance to pursue a PhD in a topic that perfectly blended my interests in linguistics and psychology with the focus on the development of structural representations in monolingual and bilingually-raised children. Under Prof. Allen's guidance, I was able to acquire invaluable knowledge and skills which broadened my research abilities. She provided me with exceptional training, encouraged me to present my work at conferences across the globe, and gave me the freedom to explore a variety of methodologies and approaches within the field.

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Chapter 1: Introduction

1.1 Theoretical background and research aims

One key question in the field of language acquisition revolves around how children detect complex, abstract patterns in language and apply these patterns to create grammatically and meaningfully structured sentences. For instance, how do they understand that sentence structures are not only dependent on the specific words used but are also crucially built on abstract categories, such as nouns, verbs, and adjectives, that can be filled by various words in different contexts? The process is further complicated by the need for children to understand that certain categories, like verbs, not only have their own properties but also govern how other words in the sentence interact. For example, children must learn that verbs like "call" require an object, while verbs like "cough" do not. Eventually, children create abstract mental representations that allow them to generalize across categories and apply newly learned words to structures they may have never encountered before. On these grounds, one of the key questions in child language acquisition literature is the nature of children's early structural representations and when these become abstract and thus, more adult-like. Two main theories have emerged from these observations: the Early Abstraction Account and the Lexicalist Account. The Early Abstraction Account (nativist view) posits that children are born with innate knowledge of syntax, using this to extract relevant patterns from language input (Chomsky, 1965; Fisher, 2002b). In contrast, the Lexicalist Account (usage-based view) suggests that children learn syntax gradually through exposure, beginning with semi-abstract representations that develop into more abstract categories over time (Tomasello, 2000). Research supports both theories, but additional factors—such as language ability, language type, and individual differences—have been shown to influence language acquisition. This led to a third, hybrid theory: the Graded Abstract Representation Account (Lieven & Tomasello, 2008; Tomasello, 2003). This account proposes that children have early abstract representations, but they are comparatively weaker than those in older children or adults. As a result, more sensitive experimental methods are needed to detect them. Increasing evidence is shifting the consensus toward this combined approach, which incorporates both lexicalist and early abstraction views.

Among the many methodologies used in acquisition research, one of the most powerful for studying early child representations is *structural priming* (Bock, 1986; Bock & Griffin, 2000). This method has proven particularly insightful in understanding how syntactic information is stored, accessed, and processed. In a typical structural priming experiment,

participants are exposed to a sentence using one variant of a structural alternation; for example, either a double-object (DO) construction (e.g., "The lawyer shows the judge the picture") or a prepositional-object (PO) construction (e.g., "The lawyer shows the picture to the judge"). They are then asked to describe a picture that represents a ditransitive event. Research has shown that participants are more likely to reproduce the structure they were previously exposed to (e.g., the DO structure "The painter sent the clown the picture") when describing a new event, rather than the alternative possibility (e.g., the PO structure "The painter sent the picture to the clown"). This phenomenon occurs even when no lexical information from the previous sentence is directly relevant, suggesting that the structure itself is activated in the participant's mind. The facilitative effect of reusing the same structure indicates that abstract structural representations are activated during processing, providing strong evidence for the existence of such representations in adults (Bock, 1986). Structural priming was initially used with adults before being applied to children, where it proved valuable in assessing whether children can generalize lexical input to abstract structural representations, independent of the specific words they have been exposed to. In relation to the early acquisition theories, a priming effect in children—especially in the case where no lexical items (such as verbs or nouns) are shared between the prime and target—would suggest that children possess abstract structural representations, supporting the early abstraction account. On the other hand, if children do not show a lexically-independent priming effect, it would favor the lexicalist view. A weak or graded representation account predicts that children develop stronger abstract representations as they age, leading to weaker priming effects at younger ages, which gradually increase as they get older. The literature over several decades has revealed many new insights into which factors modulate priming effect sizes, predominantly in adults, whereas specifically developmental stages of such factors have clearly not been sufficiently researched. Although during the past two decades the number of researchers employing structural priming methodology in children continues to grow, most research has been devoted to monolingual English-speaking children. To advance the field, it is essential to extend this research to typologically diverse languages with different distributional patterns of alternations. Moreover, there is need to adopt more naturalistic study designs, which have been successfully used in adult research, and investigate more factors influencing structural priming across a broader developmental span.

In the present work, we investigate structural priming effects in monolingually-raised and bilingually-raised German-speaking children. As previously reported, while there is a significant body of research on structural priming in monolingual children, the focus has been

on English speaking children (Bencini & Valian, 2008; Bidgood et al., 2020; Branigan & McLean, 2016; Branigan & Messenger, 2016; Branigan et al., 2004, 2005; Buckle et al., 2017, 2024; Gambi & Messenger, 2023; Gerard & Keller, 2010; Goldwater et al., 2011; Havron et al., 2021; Huttenlocher et al., 2004; Kidd, 2012a, 2012b; Kumarage et al., 2022; Messenger, 2021, 2022; Messenger et al., 2011a, 2011b, 2012; Morris & Scheepers, 2015; Peter et al., 2015; Rowland et al., 2012; Savage et al., 2003, 2006; Serratrice et al., 2015; Tafuri & Messenger, 2024; Thothathiri & Snedeker, 2008a, 2008b; Wolleb et al., 2018) with other languages receiving only limited attention. Moreover, priming research within one language in bilingually-raised children remains notably scarce (Unsworth, 2023; Wolleb, 2015; Wolleb et al., 2018). Further, much of the existing research on monolingual children has focused specifically on the presence or absence of abstract representations in children as young as 3 to 4 years of age (Bencini & Valian, 2008; Branigan et al., 2004; Huttenlocher et al., 2004; Messenger et al., 2011a; Savage et al., 2003, 2006; Shimpi et al., 2007; Thothathiri & Snedeker, 2008a, 2008b), while our understanding of how children's representations develop across growing age is still quite limited. Further, research on priming in monolingual and bilingual adults has also revealed a range of additional robust and systematic effects that modulate the priming effect size both immediately and over time, making it essential to investigate whether and how these phenomena manifest in children. Beyond *abstract (lexically-independent) priming* effects, adults show enhanced priming driven by lexical repetition (*lexical boost*), structural frequency of the structural alternation in the population (*surprisal*), and repeated exposure to the same structure (*cumulative priming*). In the present work, we intend to focus on these four core priming effects, three of which remain largely unexplored in the child literature. We next outline the three effects in more detail.

A *lexical boost effect* refers to a substantially higher priming effect when lexical items between the prime and target are repeated compared to when the prime and target do not share any lexical items (Cleland & Pickering, 2003; Pickering & Branigan, 1998). While lexical boost effects have been well-researched in adults, research on this phenomenon in children remains limited, yielding contradictory findings regarding its existence (Branigan & McLean, 2016; Kumarage et al., 2022; Peter et al., 2015; Rowland et al., 2012). Due to contradictory results across studies, there is a strong indication that the lexical boost effect may be a developmental phenomenon. This effect is important to investigate in children because it is generally associated either with the emergence of connections between syntactic representations and verb lemmas or with the retrieval of explicit memory cues to lexical items and syntactic forms.

Surprisal or so-called *inverse frequency effects* imply that individuals are sensitive to probabilistic information in their input and possess the relevant biases within their abstract representations (Jaeger & Snider, 2008; 2013). When primed, adults tend to show increased priming effects for infrequent structures, which result in immediate implicit learning effects. To date, only two studies (Fazekas et al., 2020; Peter et al., 2015) investigated surprisal effects in English-speaking children, manipulating the predictability of PO and DO structures as a function of the verb's bias. However, these studies showed conflicting results, highlighting the need for further research.

Finally, the literature showed not only short-term priming effects in the subsequent experimental trial, but also longer-term priming - the *cumulative priming effect* - the phenomenon that hearing a prime throughout an entire experimental session increases the production of the primed structure due to accumulating experience (e.g. Bock & Griffin, 2000; Bock et al., 2007). Crucially, this observation supports the notions of implicit learning strategies and adaptation to infrequent or atypical structures in the human mind. Most child priming studies have investigated cumulative effects in blocked designs where each child was exposed to a block of the same prime structures and was then asked to describe a block of target pictures (Gámez & Shimpi, 2016; Huttenlocher et al., 2004; Kidd, 2012a, 2012b; Savage et al., 2003, 2006; Serratrice et al., 2015; Tafuri & Messenger, 2024). Only two studies to our knowledge have tried to use a design on a trial-by-trial basis with prime-target pairs that allow to differentiate between immediate and cumulative effects within one experiment (Branigan & McLean, 2016; Messenger et al., 2011a). The results are rather unresolved as they either suggested an absence of cumulative effects or found different results depending on the type of coding used.

Although several theoretical accounts have attempted to explain the mechanisms responsible for structural priming effects, the most convincing theory on child priming is the *Implicit Learning Account* (Bock & Griffin, 2000; Chang et al., 2006) because it can explain both child priming performance across development and the stages of language acquisition. On this account, structural priming is a result of implicit learning that works immediately after an incoming sentence and across time. Importantly, the model relies on the prediction of upcoming words in a sentence (prime) but also accounts for base-level (initial) structural biases that are built throughout one's life and form base-level representations in our mind. The more infrequent incoming sentences are, the more weight changes in the internal structural biases are caused immediately and across time due to prediction error. Such changes are hypothesized to take place across our entire life and make us implicitly learn

structures and the probabilities with which they occur in the current environment. According to this theory, surprisal effects and cumulative effects are predicted to gradually decrease with growing age, because with more language experience, we gain more well-established representations that are less prone to prediction error. The lexical boost effect, on the other hand, is predicted to increase across age because it is assumed to be the result of a different cognitive mechanism – *explicit memory* – which is hypothesized to be weak in early childhood but develops with growing age. In this work, we plan to test this account in both monolingually- and bilingually-raised children.

Bilingual children receive special attention in our work because these children receive substantially less input in each language compared to their monolingual peers, and there is very little research on structural priming within one of the languages spoken by a bilingual child. Priming studies with bilingual children typically focus on cross-linguistic priming effects where the prime is in language A but the target is in language B (Gámez & Vasilyeva, 2020; Unsworth, 2023; Vasilyeva et al., 2010; Wesierska et al., 2025; Wolleb, 2015; Wolleb et al., 2018). However, a small number of these studies have included a within-language control condition (Unsworth, 2023; Wolleb, 2015; Wolleb et al., 2018). The focus of these studies was to study whether a child's bilingual brain is already shaped by shared representations for structures between the two languages. Research shows that bilingual children acquire two language systems simultaneously and develop abstract structural representations for both systems. However, these two systems are not entirely isolated and can be influenced bi-directionally, especially during early stages of acquisition (Genesee, 2008). Therefore, it is crucial to explore how fully established these systems are at the level of abstract structures and whether they remain unaffected by the influence of the other language. The only study that specifically focused on within language priming in bilinguals was conducted by Gámez and Vasilyeva (2015). However, the children involved had very low proficiency in English, having acquired the language as an L2 in a childcare classroom setting.

Among bilingual child studies, there is also no study testing children as young as three years of age (most research has been conducted starting from age 4;5). Our work aims to address this gap by exploring whether children as young as three already possess abstract structural representations in one of their languages, and how these representations evolve with increasing language experience. Importantly, to our knowledge, no published studies have demonstrated the lexical boost effect, and surprisal or cumulative effects remain extremely understudied within one language in bilingual children.

In addition to the contribution of this work in taking a developmental approach to studying well-established core priming effects in adult research, another significant contribution is the extension to languages other than English. This allows us to examine different probabilistic distributions of structures, where one structure is much more prevalent in the population than the other. Such structures are particularly interesting in relation to verb-argument linking (such as in PO and DO structures) and provide valuable insights into the development of both abstract and lexically specific representations in children. Therefore, this research lays a solid foundation for investigating surprisal and cumulative effects, as these structures contain essential probabilistic information. This information can enhance our understanding of processing mechanisms in children, as frequently occurring structural options lead to strong abstract representations, while infrequent structural options result in much weaker representations or may even be lacking altogether. This distributional pattern is evident in the German dative alternation. In German, there is a significant bias towards the direct object (DO) structure, and young children rarely encounter the alternative prepositional object (PO) construction. Compared to constructions like passives (versus actives), both structures are relatively simple in syntax, making them easier for children to learn. The main factors that hinder children from acquiring the less frequent variant are probabilistic in nature. For adults, the distribution follows a similar pattern; however, unlike children, they have been exposed to the PO structure throughout their lives and show a roughly 20% bias toward using it. It is hypothesized that adults have developed abstract representations of the PO structure. This hypothesis is supported by both the literature on datives in German and the results of three of our own pre-studies conducted prior to designing our priming experiment with children. These findings will be discussed in detail in Chapter 4.

There is very little literature investigating structural biases in the child literature. We know of two studies conducted by Peter et al. (2015) and Fazekas et al. (2020) who investigated verb-bias effects for PO and DO structures in English and reported contradictory outcomes. For these reasons, it is crucial to focus on the extent of priming effects by incorporating probabilistic information. We examined the properties of the German dative alternation, and based on our findings, we became interested in the typological and probabilistic factors that might influence children's priming behavior. Specifically, our focus was on the structural frequencies with which these alternations occur in the language, rather than on verb-specific bias effects associated with each syntactic alternative. To our knowledge, there are no existing studies that address this specific focus in the context of dative alternations in children. Most related work has concentrated on the active–passive

alternation, where the structural frequencies of the alternatives tend to be similar across the majority of languages studied through priming. Based on these assumptions, we formulated the following research questions and hypotheses concerning monolingual children:

1) What are the structural biases that children possess for the PO and DO structures? Due to distributional regularities in the input, children should produce substantially more DO structures and occasionally produce PO structures. The Implicit Learning Account predicts that with increasing age, the production of the dispreferred PO structure should increase due to more experience with the language, irrespective of priming.

2) How do abstract structural priming effects develop across increasing age? If structural priming effects are a form of implicit learning, they should be much stronger for the PO structure than for the DO structure. Importantly, we should observe an increase in PO production after priming with PO structures, compared to both priming with DO structures and the children's initial PO production prior to priming. Also, because young children's representations for PO structures are less stable (or weakly represented), they should show the strongest priming effects compared to older peers, reflecting surprisal. However, any abstract priming effect is only possible if children possess an abstract representation for these structures.

3) Will children show a lexical boost effect, and, if yes, when will it emerge? The Implicit Learning Account supports the assumption that a lexical boost effect is generated through working memory. The repetition of lexical information serves as an additional lexical cue for the structure it occurs in. Since a child's working memory skills improve with increasing age, the lexical boost should also gain in strength across development.

4) Will children show a cumulative priming effect by producing more PO structures with increasing trials across the experimental session, irrespective of prime type? If priming is a form of implicit learning, we should find cumulative effects across all age groups, with the strongest learning effects in the youngest children, as previously predicted for immediate priming. These effects should decrease with increasing age due to more language experience, resulting in less prediction error.

With respect to bilingually raised children, the German dative alternation represents even more interesting research questions. Bilingual German-speaking children are less exposed to German than monolingual children because they interact at least some (if not half or more) of their time in the other language. Hence, although these children should have acquired the DO structure due to its high frequency of occurrence in the input in German, it is not clear whether they have already acquired the alternative (PO) structure. Since the PO is

rarely encountered in monolingual child input for German-speaking children, we assume that the PO should be encountered even less in a bilingual environment in German. However, if the bilingual child has prior experience with a PO structure in the other language, cross-language influence may potentially facilitate the acquisition of that structure. Further, while there are some attempts in the literature to extend the implicit learning theory to cross-language priming in bilinguals, there is no extension of this theory to the mechanisms operating within one language of a bilingual. Since early bilingual children who acquired both languages either simultaneously or very early (up to age three) during childhood go through very native-like acquisition processes, we hypothesize that they go through similar processing stages during priming to monolingually-raised children, with the only difference that the speed of language acquisition might be delayed such that some structures may not be fully acquired yet at the same time point as for monolingual children. However, we also know that during the early stages of language acquisition, the two language systems can influence each other and language patterns in the background language can influence structural choice in the target language or the other way around (Genesee, 2008). Nevertheless, depending on proficiency and stage in development, children can distinguish efficiently between the two language systems and the representations that belong to them. We therefore hypothesized that they will perform at a native-like level (or just minimally different) to their monolingual peers during priming and that the theory of the Implicit Learning Account can also account for bilingual child processing when applied to contexts within one language. Specifically, we hypothesized that if bilingual children have acquired the properties of the distributional patterns of structures in the target language and possess abstract knowledge of the PO and DO structures, they should show priming effects and the Implicit Learning Account should also be applicable to the processing of bilingual children. Furthermore, the consensus in the adult literature is that there is little or no influence of structural realizations from one language on the other during priming at high proficiency levels (Kim & McDonough, 2008; 2016; McDonough, 2006; Ruf, 2011; Shin & Christianson, 2012). We therefore assume that early bilingual children will be weakly affected by the other language or not at all. On these grounds, we are interested in the following research questions concerning bilingual children:

1) Are bilingually-raised children sensitive to the structural biases in German? If yes, they should show more DO production at baseline than PO production, or no POs at all if they have not acquired the structure yet.

2) Do bilingually-raised children already possess abstract structural representations for the dative alternation in German, and if yes, at which age do these emerge? If we find abstract

priming effects in each age group, this would suggest that bilingual children possess abstract representations. However, if the establishment of abstract representation requires a particular amount of experience with the language, we will not observe priming effects in the younger children. As predicted for the monolingual children, if the structural bias in bilingual younger age groups is heavily shifted towards the DO compared to older children, they should presumably also show an enhanced priming reflecting stronger surprisal.

3) When does the lexical boost effect emerge in bilinguals? If the Implicit Learning Account is true and the lexical boost effect is indeed caused by working memory, and given that bilingual children presumably do not differ from monolingual children in fundamental language-independent cognitive abilities, we should observe that the lexical boost effect develops with increasing age at similar stages of development as in the monolingual peers.

4) Will bilingual children show cumulative priming effects? Assuming that bilingual children are aware of the structural bias in German, we should find cumulative priming effects in all groups similar to the monolinguals, reflecting adaptation to rarer alternatives through increasing exposure. Because the younger children have less experience with the language than their monolingual peers and older bilingual peers who have more well-established representations, younger children should also show the highest cumulative effects, which reflect higher learning rates of more surprising structures.

5) Is the priming behavior of bilingual children affected by structural properties of a bilingual's other language? If a bilingual's other language contains the PO alternative, it might boost the priming effect in German. To control for cross-language effects, we will account for the structural realizations in the bilingual's other language and take this as an additional predictor into our analyses. However, since recent literature in adult bilinguals suggests very minor influence of the L1 onto L2 if L2 proficiency is high, we do not expect to find a cross-language effect in the simultaneous or successive bilingual children since they have native-like linguistic proficiency.

In this thesis, we will apply a structural priming paradigm in order to study abstract and lexically-dependent (lexical boost) structural representations as well as surprisal and cumulative effects in monolingual and bilingual children and how these are influenced by prior input in a real-time dialogue. In addition to that, we will study how children's representations are shaped before they undergo an experimental procedure in which they are primed. Most importantly, we will investigate priming behavior across age and take a developmental perspective which will enable us to study changes in structural representations due to maturation. We report on the methodology and results in detail in Chapter 6.

1.2 Contents

In Chapter 2, we will revisit the key topics introduced in the introduction and delve deeper into the ongoing debate surrounding the emergence of abstract structural representations. We will also provide a more detailed exploration of priming literature in both children and adults. Specifically, in Section 2.1, we will cover the early abstraction versus lexicalist accounts (Section 2.1.1), early acquisition in monolingual versus bilingual children (Section 2.1.2), syntactic priming as a method to study representations (Section 2.1.3), and core priming effects found in adult literature (Section 2.1.4). In Section 2.2 we will review previous literature on priming in both monolingual and bilingual children and adults. In Section 2.3, we will discuss the most prominent priming theories proposed in the literature that explain child and adult behavior most persuasively.

In Chapter 3, we will present the background literature on the dative alternation in German among children and adults, comparing it with the extensive research on the same phenomenon in English. We will cover findings on probabilistic approaches in the German vs. the English literature (Sections 3.1 and 3.2), extend these insights to research on the development of the two structural alternatives in monolingual children, along with cross-linguistic influence on the dative alternation in bilingual children (Sections 3.3 and 3.4). These outcomes served as an important basis that motivated us to study priming behavior on dative alternation in German-speaking children and adults (Section 3.5).

In Chapter 4, we will introduce the three studies on the use of the dative alternation in German that we conducted with German-speaking adults (sentence completion task and acceptability judgement task) and children (analysis of child- and child-directed speech in German-speaking children between the ages 1;6 – 7;5). The studies with adults comprise a published article (Section 4.2), while the study with children is in preparation (Section 4.1).

In Chapter 5, we will introduce the two priming studies: the first involving only monolingual children and adults (Section 5.2), and the second focusing only on bilingual children and adults (Section 5.3).

Finally, in Chapter 6, we will summarize the findings and the theoretical relevance of the research discussed throughout this thesis (Section 6.1 and 6.2), followed by conclusions (Section 6.3), references for the frame text (Section 6.2), complementary attachments (Section 6.3), and a curriculum vitae (Section 6.4).

1.3 Publications

Publications and work in progress included in this cumulative dissertation:

Kholodova, A. & Allen, S. E. M. (2023). The dative alternation in German: Structural preferences and verb bias effects. In E. Zehenter, M. Röthlisberger, & T. Colleman (Eds.), *Ditransitives in Germanic languages: Synchronic and diachronic aspects* (pp. 264-298). John Benjamins. https://doi.org/10.1075/sigl.7

Kholodova, A., Peter, M., Rowland, C., Jacob, G., & Allen, S. E. M. (2023). Abstract priming and the lexical boost effect across development in a structurally biased language. *Languages, 8, 26*4. https://doi.org/10.3390/languages8040264

Kholodova, A., Jacob, G., Peter, M., Rowland, C., & Allen, S. E. M. (under revision). The development of abstract structural representations in bilingual children – evidence from structural priming. *Journal of Child Language.*

Kholodova & Allen (in prep): Corpus analysis on child and child-directed speech on the dative alternation (DA) in German.

Recent publications unrelated to this dissertation:

Jacob, G., Katsika, K., Family, N., Kholodova, A. & Allen, S. E.M. (2024). Evidence for a constituent order boost in structural priming. *Glossa Psycholinguistics, 3*(1), 1–26. https://doi.org/10.5070/G60111517

Karkaletsou, F., Kholodova, A. & Allen, S. E. M. (2024). Exploring bilingual adaptation to structural innovations: Evidence from Canadian French. *Languages*, 9(12), 375. https://doi.org/10.3390/languages9120375

Chapter 2: Syntactic Priming

2.1. Research and methods to study representations

2.1.1 Early abstraction in children

When children learn to produce sentences, they must become aware of the complex grammatical rules of their language. First, they need to develop categories for words that follow the same rules (such as verbs, nouns, adjectives, etc.) and recognize early on that the strings of words they hear in the input are not chosen arbitrarily but instead form a meaningful message based on abstract and complex syntactic patterns. One of the main tasks for children in learning argument structure is determining which arguments can appear with different categories of verbs. For example, consider a child who wants to convey the message of 'reading a story.' The child might say, *The mother read a story*, using the verb *read* transitively (with a direct object). Alternatively, the child may say, *The mother read a story to my sister*, using the verb *read* ditransitively (with both a direct and an indirect object). Another option might be to omit the object altogether: *The mother read silently*. The child's task in the acquisition process is to learn that the verb *read* verb can appear in three types of constructions, depending on the message being conveyed. However, a verb like *see* can never be used ditransitively (*The mother sees a story to my sister* is ungrammatical), even though it belongs to the same general category of transitive verbs. Moreover, the child must know that a verb like *sneeze* can usually only be used intransitively (with no direct object): *The mother sneezed several times*.[1] Similarly, verbs like *see* and *look* can denote very similar processes, but the first is transitive (*My sister saw a cat*), and the latter is intransitive and cannot be used transitively (*My sister looked a cat*). These examples illustrate that children know more about language than just word order—they must also develop more abstract representations of how to use language effectively.

There is ongoing debate in child language acquisition research with respect to the nature and extent of children's syntactic representations, their onset during linguistic development, and how such representations evolve with age. Two main theories have been proposed about the early development of linguistic knowledge in children: The ***lexicalist account*** and the ***early abstraction account.***

[1]However, even for intransitive verbs exceptions exist. For instance, *The man sneezed the napkin off the table*, or *The storm sank the ship*, where the verbs *sneeze* or *sink* is used transitively (Goldberg, 2006; Levin, 1993; Rappaport Hovav & Levin, 1998).

Lexicalist account: The lexicalist account based on usage-based learning theories arose from naturalistic studies of early language development. The main idea is that syntactic acquisition is induced by social and cognitive skills and achieved by structural repetitions from the input (Tomasello, 2000). Data showed that children's usage of lexical items closely mirrors the input and that generalizations to an argument structure over individual words or learned phrases increase with more statistical input across age (Lieven et al., 1997; McClure et al., 2006). One of the very first researchers to detect such acquisition patterns was Tomasello (1992) who did a corpus analysis of his daughter Travis' between age 1;0 and 2;0 in which he focused on her development of verbs and other predicates. He observed that she did not apply the same syntactic rules to verbs of the same category. Instead, she used some verbs in simple structures and others of the same category in more complex structures. Further, the formation of syntactic patterns began with basic simple forms and developed into more complex patterns as she got older. As a result, Tomasello hypothesized that children's representations are lexically specific - bound to particular words such as verbs which are not linked to other verbs at the beginning of development. In particular, he assumed that children's early grammatical knowledge contains sets of lexically-specific predicate structures (so-called verb islands with their own structural realization), which can be filled with nominals based on what they have encountered in the input. By extracting elements from the input and appropriately filling them into the slots of various constructions, children apply socio-cognitive skills, such as pattern recognition, which they also use successfully in other types of learning (Tomasello, 2003).

For instance, when a child learns a transitive verb like *kick,* she notices from the input that it is most commonly used with objects like *ball* or *boy* (*John kicks the ball/the boy*) and recognizes a consistent pattern: there is *kick + something/somebody*. Over time, she realizes that there are many nouns which can be used with *kick (kicks the cat/the toy)*, but this awareness only holds for this specific verb. This is what is meant by 'children have no link to other verbs yet' and, therefore no abstract category for transitive verbs. With increasing age and more repetitive input, a child discovers analogies between verbs like *kick* and *see* and adds more verbs of this category that work similarly (*verb + something/somebody*). Such processes gradually develop into an abstract category of a transitive construction such as subject-verb-object. Through distributional regularities from the input, a child becomes aware that the same rules can be applied to such categories and slowly moves away from item-specific syntactic frames. Tomasello also pointed out that it is not evident whether children

generalize or just imitate the structures surrounding them. The results of his novel verb study in 2000 indicated that a three-year-old's use of new verbs simply mimics the input.

Usage-based learning was supported in a series of elicited production studies. In several *weird word order* paradigms (Abbot-Smith et al., 2001; Akhtar 1999; Matthews et al., 2005), English and German-speaking children listened to events described with both familiar and unfamiliar verbs (e.g., *Ernie Bert pushing* where Ernie is pushing Bert or *The frog is pushing the lion* where the lion is an agent and the frog is a patient). After listening to such anomalous sentences, children freely described similar events. The results showed that children younger than 3;6 used the correct word order for frequent familiar verbs. However, for unfamiliar verbs and novel verbs, children kept producing weird word order or did not use the verb at all. French-speaking children were found to follow the same strategy (Matthews et al., 2007). More evidence for usage-based learning comes from novel verb generalization studies. Tomasello & Brooks (1998) modeled transitive (e.g., *Jim is tamming the car*) and *intransitive* (e.g., *The ball is dacking*) constructions with novel verbs. Afterward, the experimenter asked a question that elicited a transitive structure. After transitively modelled structures the children produced transitive sentences (e.g., *He's tamming the car*), but for intransitively modelled sentences children produced very few transitive utterances. Another method used to investigate children's representations involved training of intransitive, transitive, and passive-transitive constructions with well-established verbs. Later, children were presented with novel verbs in intransitive and passive-transitive constructions and encouraged to produce them in transitive constructions. The group of children that were trained produced significantly more transitive utterances than the untrained group, suggesting that abstract representations of transitive sentences are modulated by input frequency (Abbot-Smith et al., 2004; Childers & Tomasello, 2001). But there are also many more factors that influence the pace and manner of how abstract representations evolve. There is evidence that the language that children are born into plays an important role in syntactic formation (de Marneffe et al., 2012). Further, individual verbs and structural frequency affect argument structure learning patterns.

Early abstraction account: Contrary to the lexicalist account, the early abstraction account claims that children acquire abstract categories from early on. This assumption is based on the theory that in all languages of the world, words must be organized by grammatical rules to be combined into well-structured and sensible sentences. Evidence from early child language acquisition literature suggests that children show sensitivity to the rules for how to link lexical items to syntactic frames without explicit instruction and even before

they acquire extensive vocabularies. If this is true, then children's acquisition of syntax is based on some innate knowledge of syntactic patterns and their rules, such as phrase structure or verb argument frames, which can be filled with new lexical items as children's vocabulary expands (Gleitman, 1990; Fisher, 2002a; Lidz, et al., 2003; Pinker, 1984). The early abstraction account, therefore, assumes that children's early representations are abstract and emerge at a very early stage of development (Chomsky, 1965; Naigles, 1990). For example, the syntactic bootstrapping theory (consistent with the generative linguistic approach) assumes that children break into argument structure with the help of their innate linguistic knowledge. They possess knowledge about syntactic categories from early on, such as nouns, verbs, and adjectives, and are aware of syntactic relations between such categories. Evidence for such hypotheses comes from novel verb studies showing that children are able to extend their syntactic knowledge to new verbs (Fisher et al., 1994; Fisher et al., 2010; Yuan & Fisher, 2009). They can detect general syntactic patterns in the input and reincorporate these with new lexical knowledge. For instance, when a child encounters a sentence like *The rabbit ziffs the ball to the elephant* the child can quickly acknowledge that *ziffs* is a verb and probably refers to the category of transfer, such as *kick* or *bring*, and that a verb like *see* or *run* is unlikely to appear within this argument structure. In a study conducted by Yuan and Fisher (2009), children in the age range between 2;0 – 2;5 were able to derive subcategorization properties from novel verbs that are typically acquired in natural speech. Interestingly, this process does not require any visual cues. According to the theory, children also possess knowledge about thematic roles and their semantic realizations, such as agents and patients which they can also link to syntactic categories such as subject and object. Naigles (1990) used a preferential looking paradigm to show that 2-year-old children can assign meaning to a novel verb by applying word order knowledge. Gertner et al. (2006) extended this work with slightly younger children, demonstrating that 1;9- and 2;1-year-old toddlers correctly interpreted novel verbs in transitive sentences by using knowledge of English word order. Children were presented with two video clips simultaneously with an agent-verb-patient event in two opposite directions (e.g., *duck gorping bunny* vs. *bunny gorping duck*). Children were found to look longer at the video for which the semantic role matched the syntactic role during an accompanying utterance (for both agent-subject and patient-object). Several follow-up studies confirmed these results by using preferential-looking tasks, act-out-tasks and forced choice pointing paradigms (Chan et al., 2010; Dittmar et al., 2008a; 2008b; 2011; Fernandes et al., 2006; Noble et al., 2011). For instance, Conwell and Demuth (2007) found evidence for early abstract representations in a production task with

novel dative verbs in which three-year-olds were able to generalize a novel modelled verb in the DO construction *I pilked Peter the cup* to the alternative PO form *I pilked the cup to Peter* and the other way around, but less often in the latter direction. The authors believe that the preference for the prepositional dative can be due to more experience with the PO structure and that structural frequency might affect the results. Several studies have also shown correct interpretations of verb meaning under low information – for example, when both arguments in a sentence are represented by pronouns rather than explicit nouns. This shows that children are able to use syntactic and contextual information to differentiate meanings of verbs. They are also able to differentiate between meanings of mental state verbs such as *believe* and *love* and perspective verbs such as *chase* vs. *flee*, and can derive meaning not only from syntactic frames but also from the properties inherent to the verb itself (Fisher 1996, 2002b; Fisher *et al*. 1994, Papafragou *et al*. 2007). The precise nature of abstract representations in children varies from theory to theory, but crucially, according to studies confirming early abstraction accounts, children's syntactic knowledge does not go through a lexically-dependent stage during their syntactic acquisition process.

Overall, both accounts are supported in the literature to a similar extent. However, there are also studies challenging both accounts and supporting a mixture between the two. Primarily, criticism arose through several additional observations in previously conducted studies and other studies such as child-specific differences (individual differences, linguistic ability, fatigue), task differences (procedures and experimental paradigm types), production vs. comprehension differences, language-specific factors such as construction, and verb differences as well as the frequency with which verbs and constructions occur in the input. For these reasons, a third theory emerged, proposing a graded nature of syntactic representations that emphasizes the relationship between abstract representations and lexically-specific learning.

Weak or graded abstract representations: Although the lexicalist account offered many valuable insights into child syntactic acquisition, the lack of early abstractness could be due to other factors than item-based acquisition. Fisher pointed out that, in fact, some children in studies supporting item-based representations generalized novel verbs to more abstract frames and changed to grammatical word order in weird word order paradigms (Abbot-Smith et al. 2001; Akhtar, 1999; Brooks & Tomasello 1999; Kline & Demuth, 2014). She believed that young children have abstract representations for instance for transitive syntactic frames of certain kinds, but these are much weaker compared to older peers and adults because they have not yet reached all aspects of abstractedness for this category. Therefore, children can

operate at an abstract level for some syntactic operations, but not for others. This idea was derived from her observation that many child studies examined production patterns that require relatively strong representations and higher performance demands whereas comprehension studies are more sensitive to weaker representations and have demonstrated early abstract representations in two-year-olds. Similarly, Yang (2002, 2006) suggests that children start with partial abstract grammars and gradually develop more adult-like grammar through input-driven selection. Interestingly, Fisher also considered a priming effect that could have caused persistent use of the same structures (see Section 2.1.3 for more detail). The assumption that different task types might entail different outcomes triggered researchers to study children's performance in controlled direct comparisons on two different procedures but, importantly, on the same materials. The results supported Fisher's observations by showing that children do perform differently depending on the task and that lighter task demands (such as a forced-choice pointing task or a preferential-looking task relative to an act-out task) facilitate children's processing load and enable them to demonstrate similar performance in line with their older peers (Chan et al., 2010; Dittmar et al., 2008b; Dittmar et al., 2011; Fernandez et al., 2006; Noble et al., 2011). In addition to that, Dittmar et al. (2011) demonstrated that children performed much weaker if they scored lower on language ability measures and during later trials (due to fatigue).

A very robust objection against the early abstraction account comes from research showing that language-specific factors affect children's performance. Depending on the language children are born into, they produce the same argument structures at different ages, which is an argument against innate knowledge (Abbot-Smith & Serratrice, 2015; Dittmar et al., 2008b; Ibbotson et al., 2011). For all these reasons, more and more researchers began to support the graded representation view. The central assumption of this view is that young children possess some degree of weak representations of argument structures that can be detected under carefully chosen experimental paradigms and manipulations, and are further strengthened through exposure. Finally, an effective method to study the emergence of abstract representations in children, which is well established in the adult literature, is *structural priming* – a psycholinguistic method which enables participants to extract structural information from the input and subsequently produce a sentence in which they implicitly either adapt or do not adapt to previously encountered structural frames, irrespective of any lexical information. In the next section, we will introduce this method in more detail in Section 2.1.3. We will start with the very first studies discovering priming effects within the adult literature and move on with existing literature of priming effects in monolingual and

bilingual children and adults. In the section before (2.1.2), we will first also briefly introduce early L1 vs. L2 acquisition because we will also investigate early representations in bilingually-raised children.

2.1.2 Language acquisition in early bilinguals

Early bilingualism or early L2 acquisition has been defined in several ways in the literature since the term is associated with several stages during language development. This includes the spectrum from speaking and comprehending both languages equally well to speaking only one language but hardly the other, and also other factors come into play such as the age of acquisition, proficiency level, language dominance, etc.. Importantly, as Grosjean (1989) noted, "*the bilingual is not two monolinguals in one person."* One of the most representative approaches to define early bilingualism was proposed by Sorace (2012) based on first exposure, in which simultaneous bilinguals are defined as those that acquire both language systems by age 1;0. Early successive bilinguals develop both language systems between ages 1;0 and 4;0, whereas acquisition of the second language after age 4;0 is defined as L2 child acquisition or late successive bilingualism. These timelines are further supported by research showing young children's loss of ability to distinguish between sounds that do not represent phonemes in their native language and other developmental factors affecting language acquisition (Kuhl et al., 1992; Meisel, 1989; Werker & Lalonde, 1988). However, there are several other time frames proposed in the literature regarding the definition of early bilingual acquisition, with varying age ranges suggested for when bilingualism is considered 'early' supported empirically. Some researchers define early bilingualism as the simultaneous acquisition of two languages from birth, while others distinguish between simultaneous bilingualism (learning both languages from infancy) and sequential bilingualism (acquiring one language first and the second language after a certain age, typically before the age of 3 to 6). In addition, the precise age at which a child is considered to begin acquiring a second language can vary depending on factors such as the intensity and nature of exposure to the second language, the cognitive development of the child, and the language environments in which they are raised. For instance, some studies argue that early bilingualism can extend into the age of 5 or 6, while others suggest that the critical window for early bilingual language development may close as early as 2 or 3 years. After 7 years of age, second language acquisition is considered to be still possible. However, it can become more difficult to achieve native-like fluency in pronunciation, especially in terms of accent and certain grammatical features. This variability in definitions highlights the complexity of language acquisition

processes and the influence of diverse sociolinguistic and cognitive factors on bilingual development. The main consensus in the literature is that the earlier a language is acquired, the more likely it is to achieve native-like proficiency relatively quickly.

Bilingually-raised children are often found to have larger overall vocabularies when both languages are taken into account, compared to their monolingual peers. However, despite having smaller vocabularies in each individual language, research consistently shows that the language acquisition patterns of early bilingual children largely mirror those of monolingual children. This suggests that bilingual children follow similar language acquisition patterns across development, aligning with their monolingual peers. For instance, Meisel (1989) analyzed syntactic patterns in two German-French bilingual children who distinguished between SOV word order of subordinate clauses in German and SVO order in French from early on. Bilingual children also used subject-verb agreement correctly from early on. Nevertheless, Meisel observed some quantitative differences in the bilingual children's productions suggesting minor influence. Further, children who acquire two languages from birth have been observed to go through the same language acquisition processes as monolingual children with respect to babbling, their first words and first sentence structures (Genesee, 2015). For instance, some studies observed that despite the fact that bilingual children receive only half the input for a given language from their caregivers as their monolingual counterparts do, the onset for babbling, the very first words or word combinations is the same across bilingual and monolingual children (Conboy & Thal, 2006; Genesee, 2003; Paradis & Genesee, 1996; Kimbrough et al., 1997; Maneva & Genesee, 2002). In addition, children differentiate between the two language systems from early on and can suppress the influence of the other language from the target language (Genesee, 2008; Zwanziger et al., 2005). All this literature also shows that young children can learn a second language relatively effortlessly and efficiently and quickly, attaining native-like proficiency during natural contexts of exposure.

This observation takes us to the next theory previously briefly introduced that postulates the most natural language acquisition pattern is closely interrelated to age. The *Critical Period* hypothesis of language learning suggests that during early acquisition children gain from neurocognitive abilities that are 'plastic' in nature between birth and 12 to 13 years of age (Long, 1990). It is only during this period of time when the brain is acquiring any language effortlessly and can achieve complete proficiency within a short period of time requiring no formal teaching. However, there is also a vast amount of literature showing that although there is a benefit in acquiring a language at earlier stages of development,

proficiency and end-point mastery of the language differs dramatically between different individuals based on various factors. The relationship between age and second language mastery is not linear. Language acquisition is influenced by a variety of complex factors, including the quantity and quality of exposure, age, language typology, motivation, and socio-economic context. Additionally, there is no consensus in the literature regarding the specific age at which language acquisition begins to lead to monolingual proficiency levels reliably. This highlights the multifaceted nature of language development and the numerous variables that contribute to a child's linguistic abilities. Paradis (2023) points out that children show many differences in their language abilities on an individual level and therefore, it is extremely difficult to define their stages of linguistic development across a whole group of children.

Over the past three decades, research in early bilingualism aimed to determine which factors are responsible for cross-linguistic influence (CLI) effects, including the various factors named earlier. Despite these studies and the various accounts proposed, there is no clear consensus in the literature regarding when CLI is predicted, or which factors contribute most to CLI. In general, CLI is defined as the overacceptance or overuse of specific (morpho)syntactic rules in one language that originate from the other and are typically not present in monolingual speakers. Importantly, such phenomena do not always occur in the predicted directions and have been found to vary noticeably among individual children (Foroodi-Nejad & Paradis, 2009; Nicoladis, 2002, 2003; 2006). For instance, while Nicoladis (2006) found that bilingual French-English children placed prenominal adjectives in French postnominally, although English allows only prenominal adjective placement, French monolingual children were much less likely to do so.

Another important factor that may be the cause for inconsistent results on CLI is the methodology applied across all these studies, including the bilingual sample type and sample sizes. First, language dominance has been measured as either a continuous predictor or a categorical variable and the variables predicting and defining dominance also vary from study to study. Second, cross-linguistic tasks have been designed in various ways with different language properties and different language pairs. Third, children varied in their bilingual background and age of onset of the two languages. All these differences make it extremely difficult to establish direct comparisons across studies on CLI. A recent study conducted by Dijk, Wonderen, Koutamanis, Kootstra, Dijkstra and Unsworth (2021) performed a meta-analysis in 750 simultaneous and early sequential children across 26 experimental studies to measure the effect size of CLI. The authors found small to moderate CLI effects in the

children, suggesting that CLI is an inevitable part of a bilingual child's language development. The results revealed influence at the morpho-syntactic level, in line with previous research on (morpho)syntax (Hulk & Müller, 2000; Serratrice, 2013). However, the rather small effect size suggested that although there is a small transfer from the other language, these children perform similarly to monolingual children in a relatively language-specific way. Dijk et al. (2021) also found no differences in CLI at the morpho-syntactic level governed by pragmatics versus other language domains. Hence, there was cross-linguistic influence in either surface overlap and no overlap conditions, and no significant difference across the two effect sizes. While this result did not disprove Hulk & Müller's (2000) hypothesis claiming that structural overlap across two languages for one structure may affect the use of two structures in the other language (see more details in Chapter 3, section 3.4), it contributed to the literature in finding that CLI can occur even when no properties in the two languages are shared, such that overlap in structural properties is not mandatory. In contrast to research suggesting no apparent relevance of language dominance for CLI in early bilingual acquisition (de Houwer, 1990; Schmitz, 2006), language dominance turned out to be the most influential factor to predict CLI. Because authors determined dominance in different ways, Dijk et al. (2021) found stronger CLI from the societal language into the non-societal language than the other way around, but the latter effect was still present. As previously mentioned, the authors observed a continuous influence across languages as a function of bilingualism at all stages of development rather at particular ages (in line with Argyri & Sorace, 2007; Bosch & Unsworth, 2020). The authors also argue for a more uniform approach when studying CLI as otherwise, predictors vary substantially across different types of studies. The authors also point out that in their data there was not always enough information provided about the full bilingual upbringing, that is, more content about how the two languages were acquired (one parent and one language, one language at home vs. societal language, how often each input is received, etc.) which also accounts for language dominance. Moreover, the authors do not rule out the possibility that some general bilingualism effects are also at play and that bilingual children may process in very monolingual-like manner but because they receive substantially less input or experience higher cognitive load compared to monolingual peers, they might perform poorer on the tasks.

While numerous studies have explored the roles of age, exposure, cognitive abilities, and the context in which the second language is learned, the precise combination of these factors that leads to native-like proficiency remains debated. The complex interplay between

these elements makes it difficult to determine a universal formula for achieving native-like mastery in a second language. However, there is extensive literature suggesting that early bilingual children can exhibit native-like behavior in both language production and comprehension with minor to moderate cross-linguistic influence which can be detected under controlled experimental conditions. These findings demonstrate the potential for high levels of proficiency when two languages are acquired early in life.

2.1.3 *Syntactic priming as a method to study representations*

The question of how language is stored and accessed in our brain is fundamental to understanding cognitive processes and is a central issue in language acquisition and psycholinguistics. One key approach to studying this is by examining the underlying mechanisms that mediate the relationship between language input (what we hear or read) and language output (what we produce). These mechanisms help explain how mental representations in our brain are stored and used in response to language input. Because these representations are not static but are continuously shaped and refined as we are exposed to new linguistic input, in essence, language acquisition involves creating and adjusting these representations over time based on experiences with language. One of the most efficient tools to investigate these processes is *structural priming*. This mechanism provides valuable insights into various levels of human linguistic representations, including how structures are stored, how we make structural choices in production or comprehension, and the facilitative processing effects that occur after exposure to auditory or written stimuli (e.g., Bock, 1986; Branigan & Pickering, 2017; Hartsuiker et al., 2004; Pickering & Branigan, 1998; Pickering & Ferreira, 2008; Weber & Indefrey, 2009). Research has shown that individuals often unconsciously reuse structures they have encountered before, incorporating them into new productions. This effect provides strong evidence that speakers possess mental, abstract representations that go beyond individual words or lexical items, and potentially beyond small units of words. The phenomenon of reusing syntactic structures, independent of the specific lexical items used, is known as *structural (or syntactic) priming*. Notably, this effect occurs automatically at an unconscious level and is purely syntactic in nature.

The first empirical evidence for this phenomenon came from Levelt & Kelter's (1982) study with monolingual adult Dutch speakers, where they answered questions that only differed in the preposition*: At what time does your shop close?* (Dutch: *Om hoe laat gaat uw winkel dicht?*) vs. *What time does your shop close?* (Dutch: *Hoe laat gaat uw winkel dicht?*) which could be either answered with a prepositional phrase *At five o'clock.* (Dutch: *Om viif*

uur.) or just with a noun phrase *Five o'clock.* (Dutch: *Viif uur*). A series of question/answer experiments demonstrated that speakers tend to repeat elements from previously uttered sentences, particularly reusing noun phrases or prepositional phrases introduced in the prior question. However, Levelt and Kelter (1982) did not interpret these effects as evidence of syntactic priming per se. Rather, they explained the phenomenon as influence from broader discourse-level factors which caused participants to reproduce elements of preceding utterances for the sake of alignment and continuity in dialogue. It was Bock (1986) who concluded that priming may be a consequence of prior activation of syntactic frames which may be stored in our language system as abstract representations. She conducted the first syntactic priming experiment where she specifically tested whether whole structural sequences would be reproduced by participants after listening to a prime sentence. Her within-subject design contained two structural manipulations for primes: (1) transitive structures which could either be expressed in a passive or active voice or (2) ditransitive structures which could either be expressed in a prepositional object or a double object.

(1) a. *The building manager was mugged by a gang of teenagers.* (Passive)
    b. *A gang of teenagers mugged the building manager.* (Active)
(2) a. *The waitress took a tray of appetizers to the customers.* (Prepositional object)
    b. *The waitress took the customers a tray of appetizers.* (Double object)

These structural manipulations were not apparent to the participants. Monolingual English-speaking adults were asked to repeat an orally presented prime sentence and then describe a picture depicting either transitive or ditransitive events shortly afterward. The results revealed that participants were more likely to unconsciously reproduce syntactic structures for both types of sentences (transitive and ditransitive) in their subsequent descriptions, demonstrating a constituent-by-constituent computation on a purely syntactic level. These results suggest that certain cognitive mechanisms involved in sentence production are sensitive to previously used structural patterns and can adapt or incorporate them into subsequent utterances. Because there was no lexical overlap between the primed and target items, the resulting priming effect was lexically independent (purely abstract in nature), referred to here as an *abstract priming effect* (see Rowland et al., 2012, for similar terminology). This implies that speakers possess abstract syntactic representations of multiple structures, and that one of these can be selectively activated over an alternative form which may, in turn, ease the cognitive demands of message formulation. Importantly, Bock's (1986) findings also showed that structural priming effects are not dependent on the repetition of closed-class elements (such as function words), but instead reflect the priming of constituent structure, rather than linear

word order. This experimental design laid the groundwork for subsequent structural priming studies, which not only examined priming effects but also explored how abstract syntactic representations in humans are shaped and influenced by language input during relatively natural speech (e.g., Bock, 1986; Bock & Griffin, 2000; Pickering & Branigan, 1998).

Further, Bock & Loebell (1990) demonstrated that syntactic representations can be distinct from semantic representations. The authors observed priming effects for a ditransitive structure *the girl is handing a paintbrush <u>to the boy</u>* with a prepositional object of a beneficiary meaning after hearing *the wealthy widow drove an old Mercedes <u>to the church</u>* with a prepositional object of a locative meaning. These results suggested that semantic representations are distinct from syntactic representations (see Vernice et al., 2012 for Dutch). Structural priming appears to be informative about different levels of representations and thus can reveal insights into language universals (Evans & Levinson, 2009). Because different languages vary in their syntactic realizations from English, priming is a powerful tool in language sciences to study universal convergences or divergences across various language typologies. Moreover, it has been attested to be more illuminating than grammaticality judgments (Branigan & Pickering, 2017). However, most priming studies in adults investigated German or Dutch as well as some East Asian languages which showed priming to a similar extent as in English. As a result, there is still quite insufficient work in other languages of the world, different structures and modalities.

Structural priming has been found in corpus studies (Gries, 2005; Szmrecsanyi, 2005), in such modalities as speech production (Bock, 1986), written language production (Branigan et al., 1999), and dialogue (Branigan et al., 2000). Priming effects were not only found in English, but in Dutch (Hartsuiker et al., 1999) and German (Jacob et al., 2024; Scheepers, 2003; Scheepers & Corley, 2000). This has led to the conclusion that similar mechanisms are involved in priming production and comprehension. Nonetheless, it has been shown that priming effects in comprehension differ in size to production, resulting in lower magnitude (e.g., Branigan et al., 2004). Further, Bock and Loebell (1990) showed that priming is neither affected by prosodic (rhythmic) similarities nor by thematic relations across sentences. Regarding thematic relations, they examined, for example, passive primes (*The construction worker was hit by the bulldozer*) versus prepositional-locative primes (*The construction worker was digging by the bulldozer*) where in the latter example, the *by*-phrase refers to a location rather than an object. The theory implied that if priming is taking place on a purely structural level, syntactic priming effects should only occur for passive structures. The authors found exactly the predicted pattern of results with no priming for thematic roles.

The brief overview of the very first studies that tapped into priming triggered a great amount of further priming studies not only in monolingual (Bernolet & Hartsuiker, 2010; Bock et al., 2007; Gries, 2005; Hartsuiker et al., 2008; Jaeger & Snider, 2008; 2013) but also in bilingual adults (Kim & McDonough, 2008; 2016; McDonough, 2006; Ruf, 2011; Shin & Christianson, 2012; Schoonbaert et al., 2007).

The foundation for priming research in children was informed not only by studies with adults. Early child acquisition studies applying elicitation tasks observed tendencies of repetition effects after recent exposure while the term priming effect was not mentioned. For example, in a turn-taking picture description task where the experimenter described pictures in the passive form, children comprehended and produced passive structures more easily than controls who were not exposed to any passive structures (Goldfein, 1974). Hence, not long after the first decade of adult research, studies on priming in young monolingual children began to emerge. The primary goal was to investigate abstract representations and cognitive processing mechanisms in children by comparing them to those in adults. Most early studies primarily used blocked priming designs (Bencini & Valian, 2008; Gámez et al., 2009; Huttenlocher et al., 2004; Kidd, 2012a, 2012b; Savage et al., 2003, 2006; Serratrice et al., 2015; Shimpi et al., 2007), in which children were primed with one structure in a block and then exposed to either the alternative structure or the same structure again. However, these designs have received criticism for potentially eliciting training effects rather than unconscious priming effects. Despite this, blocked priming designs are particularly well-suited for investigating passive structures, which are normally never produced in spontaneous speech by young children. Because of limitations in blocked procedures, researchers have also started to develop more adult-like priming designs in which the prime structure alternated randomly throughout the experimental session and was additionally interspersed with fillers (Branigan et al., 2005; Branigan & McLean, 2016; Gámez & Vasilyeva, 2015; Kumarage et al., 2022; Messenger et al., 2011a; Peter et al., 2015; Rowland et al., 2012; Scheepers, 2003; Thothathiri & Snedeker, 2008a, 2008b). This approach better reflected the natural variation in language input and more closely resembled authentic language interactions. All these studies have greatly contributed to our understanding that even children show abstract syntactic representations and that priming functions at a purely syntactic level. One of the most significant findings from structural priming research is its ability to serve as a sensitive measure of how linguistic information is represented, stored, and modified during exposure to language beyond the mere repetition of a sentence structure. In the following subsection, I will report on core structural priming effects (that I briefly introduced in Chapter 1) that have

emerged over the past four decades of research in both children and adults, highlighting key findings and theoretical debates that continue to shape our understanding of syntactic development and representation. These findings form the foundation for the research questions addressed in this dissertation.

2.1.4 Core priming effects

Lexical boost: Over four decades of structural priming research, studies have revealed that priming effects can vary significantly in size, ranging from as low as 3-7% to as high as 15-30%. These observations have spurred a range of experimental manipulations aimed at understanding the factors and conditions that drive such variability in effects. A widely discussed effect, predominantly in the adult L1 and L2 literature, is the so-called *lexical boost* effect which causes a significantly enhanced priming effect when the prime and the target sentence share the same head verb (Corley & Scheepers, 2002; Hartsuiker et al., 2008; Mahowald et al., 2016; McDonough, 2006; Pickering & Branigan, 1998; Schoonbaert et al., 2007) For example, if the prime sentence was previously encountered with the verb *give* in a DO structure (e.g., *The women gave the child the book*) and the target sentence to be uttered also contains the same verb (e.g., *The boy gave the girl a ball*), the likelihood of using the DO construction increases. Such an effect has also been observed across a wide range of syntactic alternations with head nouns, such as pre-nominal and post-nominal relative clauses (e.g., *the red sheep* vs. *the sheep that is red*) (Cleland & Pickering, 2003) and active/passive structures (e.g., *one of the fans punched the referee* vs. *the referee was punched by one of the fans*). Lexical boost effects have been hotly debated with respect to the existence of structural and lexical connections within our language system. Stronger priming effects can be a consequence of lexical entries in our mental lexicon with a connection for the argument structures that are possible with this verb (Pickering and Branigan, 1998). Alternatively, the lexical boost effect could be related to non-linguistic factors such as working memory components (Chang et al., 2006), which are able to keep some re-occurring lexical items in memory for a short period of time and boost priming. Research has shown that the type of constituent (structure-licensing heads such as the verb vs. non-structure-licensing heads) shared between the prime and target does not differ significantly in priming effect size and that the more content words are shared between prime and target (for example, the agent+verb+recipient) the more priming occurs, which has received the term *cumulative constituent boost* in the literature (McLean et al., 2004; Reitter et al., 2011; Scheepers et al., 2017). In sum, these findings indicate that although lexically-specific syntactic frames do

exist and this has been widely shown in the literature, they do not lead to increased priming. Rather, the repetition of any type of constituent word or the amount of constituents being repeated modulates the priming effect size and suggests a different mechanism responsible for this outcome – presumably working memory. Importantly, the lexical boost effect has been found to be short-lived whereas abstract priming can be both short and long-lived. However, there is no clear consensus on which mechanisms specifically drive the lexical boost effect.

Surprisal: Further, there is much debate in the literature about enhanced priming effects for less frequent structures. For example, when a ditransitive verb occurs more often in a PO structure compared to a DO structure (such as the verb *send* in English), but is presented in the less frequent structure as a prime (the DO in this case), participants are more likely to adapt the infrequent structure and show increased priming – a phenomenon called *prime surprisal* (see Bernolet & Hartsuiker, 2010; Coumel et al., 2023; Jaeger & Snider, 2008, 2013).

Cumulative priming: Another phenomenon investigated in both the child and adult literature is *cumulative priming* which has been often shown to result directly from repeated exposure to a surprising or less frequent structure (Branigan & McLean, 2016; Fine et al., 2013; Jaeger, 2016; Jaeger & Snider, 2008, 2013; Kaschak et al., 2011, 2014; Messenger et al., 2011a; Reitter et al., 2011). This term implies that exposure to multiple primes has a cumulative effect that can persist across time and yield similar priming effect sizes as immediate priming. Cumulative priming has not only been observed in experimental studies but also occurs in corpus studies across a range of syntactic alternations, where the strength of the priming effect increases with each prime trial being presented (Jaeger & Snider 2008; Szmrecsanyi 2005). This phenomenon suggests that our language system adapts to recurring input and reshapes our preferences in our internal structural representations. However, research does not always consistently distinguish between long-term priming effects based on trial-by-trial basis vs. pre- and post-test sessions. While both terms apply to long-term learning mechanisms, in this thesis we will differentiate between the two for clarity. Specifically, *cumulative priming* refers to an effect observed within a single experimental session, where repeated exposure to a particular structure increases the likelihood of its production over the course of that session. In contrast, *long-term priming* persists beyond the priming session, where a participant's syntactic choices are usually assessed before and after a priming session. Although both forms can yield similar outcomes in terms of structural adaptation, the methodologies and temporal scope differ. Although long-term priming effects are not the focus of this work, we will discuss several relevant studies to highlight that, even

when cumulative priming was not directly examined, long-term effects have been observed using alternative methodologies. As introduced above, many of these studies converge on the idea that surprisal (prediction error) is mainly responsible for cumulative priming effects by continuously updating individual structural representations with less frequent (surprising) input, a process mediated by implicit learning (Fine et al., 2013; Jaeger & Snider, 2008, 2013; Reitter et al., 2011; Wells et al., 2009). This interplay helps to explain why repeated exposure to surprising structures leads to greater structural adaptation across time. We therefore combined the discussion on cumulative priming and surprisal in our subsections, as these phenomena are interrelated.

In the next section, we will review the literature on core priming effects, with a particular focus on how these phenomena have been studied in both monolingual and bilingual adults and children. Specifically, we will examine the extent to which research has explored structural abstract priming effects along with other core priming effects, such as the lexical boost effect, surprisal and cumulative priming. We will also summarize current findings on the differences and similarities between bilingual and monolingual individuals with respect to the core priming effects. This discussion will help illuminate to which extent previous priming research has contributed to our understanding of language acquisition, processing, and representation in both single- and multi-language speakers.

2.2. Literature review on core priming effects in children and adults

2.2.1 Priming research in monolingual adults

Most priming research conducted with monolingual adults has supported the fundamental nature of priming effects. Research has suggested that abstract priming depends on structural similarities across sentences and that a premise for priming effects to occur presupposes an entry for the abstract structural representation in an individual's mind. Very early priming studies in adults demonstrated that syntactic priming is not affected by other linguistic information, such as semantics, thematic roles[2], prosody, or by smaller-syntactic units, such as closed-class words and functions on a purely syntactic (constituent) level (Bock, 1986, 1989; Bock & Loebell, 1990; Carminati et al., 2008). Since then, structural priming has been shown in monolingual adults with a variety of structures such as transitives, ditransitives, relative clauses, garden-path constructions with a prepositional phrase in

[2] But see other research for finding priming on thematic roles (Chang et al., 2003; Ziegler & Snedeker, 2018)

dialogues, spoken and written completion, sentence recall (Bock et al., 1992; Branigan et al., 2000, 2005; Pickering & Branigan, 1998; Potter & Lombardi, 1998; Scheepers, 2003).

Abstract priming has been shown to be a universal phenomenon and not tied to particular syntactic patterns that exist, for example, in languages like English, German (Köhne et al., 2014; Pappert & Pechmann, 2014; Scheepers, 2003) and Dutch (Hartsuiker et al., 2008) which are highly studied with respect to priming. Priming effects have been found in Brazilian Portuguese, Portuguese, Mandarin, Korean, Swedish, Spanish, Russian and Italian (Cai et al., 2012; Fernandes et al., 2019; Hartsuiker et al., 2008; Kantola & van Gompel, 2011; Shin & Christianson, 2009; Vernice & Hartsuiker, 2019; Ziegler et al., 2019) and also in agglutinative, complex and verb-final languages such as Turkish (Mercan & Hohenberger, 2019). Further, syntactic priming has been observed on a word-by-word level (surface structure) and on the global structure level (such as passives vs. actives or relative clauses), irrespective of linear word order. The results are still somewhat controversial with some studies showing that linear word order is essential to observe priming (Bernolet et al., 2009; Köhne et al., 2014; Pickering et al., 2002), but other studies find effects at the global level irrespective of same word order within and across languages (e.g., Bernolet et al., 2009; Chen et al., 2013; Jacob et al., 2024; Khoe et al., 2023; Shin & Christianson, 2009).

Lexical boost effect: The very first study to demonstrate a lexical boost effect was conducted by Pickering and Branigan (1998). The authors exposed participants to incomplete prime sentences that elicited either a DO (e.g., *The mother gave the hungry baby*…) or PO structure (e.g., *The mother gave the expensive toy* …). They manipulated the prime sentences by using either the same verb in both the prime and target or a different verb. Participants were instructed to complete the prime sentence and then finish a target sentence containing only the subject and the verb (e.g., *The air hostess gave...*), which did not prompt any specific alternation type. The authors observed stronger priming effects when the prime and target shared the same verb (17.2%) compared to when they used different verbs (4.4%). Similar patterns were replicated in numerous follow-up studies, although with varying effect sizes. For instance, Branigan et al. (2000) found more priming in the lexically-shared condition (55%) than in the abstract condition (26%), which also demonstrated a substantially higher priming effect in both conditions compared to Pickering and Branigan (1998). A similar effect size was also shown in Hartsuiker et al., (2008) with 45% versus 28% between conditions respectively. These observations led to the conclusion that adult representations must also store connections to verbs. While production studies clearly demonstrated lexical boost effects, comprehension studies initially found priming effects only when verbs were repeated

across the prime and target. These studies did not provide evidence for abstract representations (e.g., Arai et al., 2007; Branigan et al., 2005; Pickering & Traxler, 2004; Traxler et al., 2014). However, more recent research has found evidence for abstract priming effects in comprehension as well (e.g., Kim et al., 2014; Pickering et al., 2013; Tooley & Bock, 2014). As the literature expands, the consensus is shifting towards the recognition of both lexical and abstract priming effects in comprehension. Findings from both comprehension and production illustrate that, unlike the abstract priming effect, the lexical boost effect is short-lived and persists over only a few intervening sentences (Hartsuiker et al., 2008; Mahowald et al., 2016; Pickering et al., 2013). This observation has led to the conclusion that abstract priming and the lexical boost effect stem from different cognitive mechanisms in language production. Some accounts attribute the lexical boost effect to a residual activation mechanism, where links between verb nodes and structures are activated, facilitating the use of the same structure through verb repetition (Pickering & Branigan, 1998; Tooley & Traxler, 2014). In contrast, other accounts suggest that information from the prime sentence is temporarily stored in long-term memory but accessed via working memory, where individual words from the prime are retained (Chang et al., 2006, 2012; Reitter et al., 2011). Consequently, when a verb is encountered in the target for a second time, access to the structural information is still activated and causes a faciliatory effect. Both approaches find support in the literature; we will describe these accounts in more detail in Section 2.3.

Cumulative priming and surprisal: Bock and Griffin (2000) were the first to demonstrate that syntactic priming can persist over longer periods of time with intervening unrelated sentences, which suggested not only immediate priming effects but also persistent priming effects. These results indicated that priming can lead to long-term changes in our internal structural preferences and may be caused by underlying learning mechanisms. These persistence effects were further confirmed by a large amount of other work in production and comprehension where researchers applied both trial-by-trial and post-test measures (Bock et al., 2007; Fine et al., 2013; Fraundorf & Jaeger, 2016; Hartsuiker et al., 2008; Jaeger, 2016; Jaeger & Snider, 2008, 2013; Kaschak et al., 2011, 2014; Reitter et al., 2011; Tooley & Traxler, 2018; Wells et al., 2009) to better understand how and to which extent long-term effects and cumulative effects evolved. All this work deeply shaped learning-based theories, such as those proposed by Bock & Griffin (2000), evolving them into adaptationist accounts. These models explain how primes can influence syntactic representations in long-term memory and remain active throughout the entire life (Chang et al., 2006; 2012; Fine & Jaeger, 2013, 2016). Crucially, most of the research agrees that learning is generally strongest when

input sentences are less expected (surprising), and therefore priming effects increase and persist over time causing cumulative effects (Fine et al., 2013; Jaeger & Snider, 2008, 2013; Jaeger, 2016; Kaschak et al., 2011, 2014; Reitter et al., 2011). Early evidence for surprisal (or *inverse frequency effects*) derives from a corpus of spontaneous speech (Bresnan et al., 2007) which contained 1108 dative utterances that were preceded by dative primes. In this corpus, Jaeger and Snider (2008) observed that the verb alternation bias modulated the priming effect size. When the sentence uttered was preceded by a PO construction with a verb biased towards the DO structure, the priming effect was greater than when the PO prime contained a PO-biased verb, respectively, as has been shown in further studies with adults (Bernolet & Hartsuiker, 2010) and children (Peter et al., 2015). Later work showed long-lasting priming effects based on surprisal. Kaschak et al. (2011), for instance, biased participants towards either a DO or PO structure via priming. They then assessed their production of target constructions and observed more cumulative effects when the biased structure was less frequent (the PO here). Reitter et al. (2011) conducted a simulation study assessing cumulative priming effects as a function of inverse frequency, which revealed robust cumulative priming for the lower-frequency PO structure, but not for the alternative higher-frequency DO construction. The authors observed more priming as the number of primes increased. These findings suggest that surprisal or inverse frequency effects not only exist at the immediate level, but also at the long-term adaptation level. Interestingly, Jaeger (2016) showed that cumulative priming effects do not differ depending on whether the verb is the same or different, which is supported by the idea that the lexical boost effect is short-lived and should therefore not transfer to long-term priming effects.

2.2.2 Priming research in monolingual children

The findings from adult priming studies over the past few decades have provided a solid foundation for investigating children's syntactic representations and their developmental processes. Researchers have sought to understand whether children's processing strategies differ from those of adults, given that children's grammar and vocabulary are still developing and undergo various stages of growth that depend on linguistic experience. As a result, structural priming became a valuable method for exploring the nature of early child representations in language acquisition. Initially, research focused on distinguishing between early lexical constructivist and early abstraction accounts. Key questions centered on whether (1) children exhibit abstract priming effects that support early abstraction theories, and (2) whether children only show priming effects when there is lexical overlap between the prime

and target, thus supporting lexical constructivist views which suggest children begin with lexically-dependent representations. The first priming studies conducted with children, typically between 3 and 6 years of age, aimed to investigate the nature of the initial representations they use (Huttenlocher et al., 2004; Savage et al., 2003, 2006). Interestingly, in these early studies, the results suggested a mix of both abstract and lexical representations, with their presence varying by age. Savage et al. (2003) found a lexical priming effect for noun phrases, specifically comparing pronouns and nouns. They tested transitive constructions that could be expressed either in an active or passive voice. These alternating structures were examined under two conditions: a high pronoun overlap condition ('It cut it') and a low noun phrase overlap condition ('The knife cut the cake'). The study involved 3- to 4-year-old and 6-year-old English-speaking children. The younger children exhibited priming effects only in the high lexical overlap condition, while the older children showed priming effects in both the pronoun overlap and non-overlap conditions. The results were interpreted as evidence for lexically-dependent representations in younger children, while the priming effects observed in both conditions for older children suggested the development of more adult-like representational networks. However, the enhanced priming effects triggered by high lexical overlap may reflect facilitation effects, as this condition requires less cognitive effort, a point also raised by Messenger in her thesis (2009, p. 42). The absence of priming effects in the low overlap condition could be attributed to the increased cognitive demands involved in producing a passive structure, which may be more challenging for younger children. Additionally, the authors employed a blocked design, with the two structures presented in separate sessions, spaced 1 to 8 weeks apart. This could have served as another reason for a preference for pronouns, because the harder the structural formation is, the more an individual is likely to search for less cognitively demanding referents. In a follow-up study, Savage et al. (2006) replicated the design of the previous experiment, but primed passive and active structures only in the high overlap condition ('It cut it'). The authors extended the procedure to another two follow-up sessions, one week and a month after the first priming session in which they did not prime children anymore and instead investigated only target child descriptions. The goal was to investigate whether the priming effect persists across time and whether children would show an accumulation of the primed structure through structural experience within a block which could be a form of procedural knowledge (e.g., Bock & Griffin, 2000; Bybee, 1998; Chang et al., 2000; Luka, 1999) and thus may contribute to learning (changing, expanding) representations. The priming effect was maintained for up to one week and up to one month if participants underwent the second session. In other words, the target responses

given one week after the priming session served as new primes for the subsequent target responses a month later. This led to the conclusion that, during priming sessions, children not only learn but also modify their linguistic representations. Furthermore, the authors observed stronger priming effects when varied verbs were used, compared to when a single verb was employed. Long-lasting priming effects in children were also confirmed by Huttenlocher et al. (2004). Furthermore, the authors were the first in the child priming literature to examine not only the emergence onset of abstract representations for passive versus active structures, but also for double object versus prepositional object structures in children aged 4;5 to 5;8 years. For datives, 10 different transfer verbs were used, which were spread over 10 dative trials. The key questions addressed in this study were (1) whether the magnitude of priming effects differs between comprehension-to-production priming compared to production-to-production priming, and (2) whether priming effects persist over a series of primes. The authors also analyzed the baseline structural use of passive vs. active constructions, as well as both dative forms, in the spontaneous speech of 4-year-old children during a 90-minute period before priming. All children produced only active sentences, and used more double-object constructions compared to prepositional-object constructions. This pattern was consistent with the findings of Snyder and Stromswold (1997), leading to the conclusion that double-object datives are acquired earlier. In two experiments the authors observed immediate priming effects for each structure type, irrespective of repetition or non-repetition of the prime structure. A separate analysis revealed no significant difference between the two experiments in priming magnitude. This suggested that listening to the prime form increased the likelihood of reproducing that form to a similar extent as when repeating the prime first and completing the target then. Building on Bock and Griffin's (2000) findings of long-term priming effects in adults, Experiment 3 primed children in blocks of each structure and then asked them to describe 10 pictures in sequence. The authors found that priming effects persisted across up to 10 trials, suggesting that exposure to specific syntactic forms facilitates learning and adaptation.

Crucially, these very first studies summarized above confirmed the existence of abstract structural representations in children not younger than 4;5 years of age, whereas 3- to 4-year-old children were confirmed to have lexically dependent representations according to Savage et al. (2003, 2006). But again, preference for lexical priming was found for pronouns and noun phrases which did not entail argument structure linking to the verb. Enhanced priming effects for these open class items could have been due to children's cognitive facilitation strategies. Further studies were conducted with the goal to answer these questions.

But importantly, most of the early child priming studies differed from adult priming paradigms in that the critical manipulations were administered in blocks, either in between-subject designs or in blocked designs (Bencini & Valian, 2008; Huttenlocher et al., 2004; Shimpi et al., 2007) where children were primed with one structure over many trials and switched then to the alternative structure over the same amount of trials, which makes cumulative effects of repeated exposure more likely to occur. However, all these designs did not allow for examining immediate priming effects as were observed in adults using a trial-by-trial design. Also, it was not clear whether the same mechanisms were operating when primed on a trial-by-trial basis or over a whole block. In other words, cumulative priming effects could be due to learning effects, whereas immediate priming effects could be due to short-term activation, especially because lexical boost effects were shown to be short-lived in adults.

Although children exhibited priming effects for passive structures when primed with passives in blocked designs, it remained unclear whether they possessed a full representation of the structural components of a passive construction, enabling them to prime effectively. Alternatively, children may have been able to parse previous input using analogy techniques, making it easier for them to reproduce similar syntactic components, such as transforming the subject of an active clause into the object (thematic role switch) in a passive construction. This would suggest that children were not yet aware of the underlying structure of passive clauses and were instead relying on learning strategies typically used for acquiring new structures. Messenger et al., (2011a) provided evidence for abstract representations (non-lexically specific structures (Tomasello, 2000)) in 3- to 4-year-old children by employing a within-subject design similar to those used in adult studies. The authors primed children with alternating active primes vs. short passive primes (*The cat was chased*) and looked at subsequent production of full passives (*The cat was chased by the dog*). The authors hypothesized that if children produced more full passives after short passive primes than after active primes, this would provide evidence that children generalize from short to full passive forms and apply common abstract representations to both structural forms. Indeed, children showed priming effects following short passive primes. The priming effect for adults (8.3%) was lower than for children (11.9%) as reported above. There was also no evidence that children produced passives only after cumulative exposure.

In a series of further experiments which also included trial-by-trial designs researchers found crucial evidence for the existence of abstract representations from early on starting with 3 to 4 years of age for passive vs. active structures (Bencini & Valian, 2008;

Bidgood et al., 2020; Darmasetiyawan et al., 2022; Konradt, 2019; Messenger et al., 2012; Shimpi et al., 2007; Tafuri & Messenger, 2024) and double object vs. prepositional object structures (Buckle et al., 2017; Goldwater et al., 2011; Messenger & Hardy, 2017; Morris & Scheepers, 2015; Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008a, 2008b). Regardless of whether participants were instructed to repeat the prime orally (production-to-production) or to only listen to the prime (comprehension-to-production), children reproduced the structure they have previously heard similar to adults. Nevertheless, in a blocked priming study with blocks of either dative or passive primes, Shimpi et al. (2007) showed that both three- and four-year-old children only showed priming when the prime was repeated before they were asked to descripe events in a subsequent dative or passive block. When children only listened to prime blocks, the three-year-olds did not show any priming effects. This highlights that the absence of structural priming effects in young children does not necessarily indicate a lack of abstract representations; instead, it may reflect task demands or other factors. Despite the fact that many priming studies find abstract priming effects, there is still considerable individual variation. Kidd (2012a, 2012b) notes that a significant proportion of children do not exhibit priming effects, with their performance being more closely linked to linguistic knowledge and non-verbal reasoning abilities, rather than age. Although priming methodology is obviously one of the most succesful techniques to study abstraction in children, much more research is necessary to accurately design and interpret studies. Some work in child priming research showed numerical trends towards increased priming effects in children compared to adults (Messenger et al., 2011a; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018). Although these trends did not reach significance, they triggered more fine-grained ideas about mechanisms generating priming effects in children and adults. All these findings served as an important contribution to the child literature on abstraction accounts and priming research, suggesting that children as young as three years of age do possess abstract representations in accordance with adults and that their syntactic representations are not tied to specific lexical entries. Children are influenced by the prime structure, maintain the prime structure at an abstract level, and finally integrate the same structural sequence into a new sentence, irrespective of content (lexical) information.

Lexical boost effect: In contrast to the broad number of child studies confirming abstract structural priming in children as young as age three, findings on the lexical boost effect in children remained very scarce and inconclusive, mainly because very little research has looked at immediate priming for verb-structure effects. Recall that Savage et al. (2003,

2006) found greater priming in the lexical overlap condition for nouns and pronouns, but not for verbs. A couple of years later, Thothathiri and Snedeker (2008b) conducted an eye-tracking priming study that contained a lexical overlap condition for verbs. In contrast to previous studies, this experiment focused solely on comprehension, involving 3- and 4-year-old children who completed an act-out task using toys. The instructions included primes and targets of imperative double object and prepositional object constructions with a phonologically ambiguous object following the verb which could either be a direct object in the DO condition (*Give the **bird** the dog-bone*) or an indirect object in the PO condition (*Give the **bird**-house to the sheep*). The authors incorporated a verb overlap and non-overlap condition for primes and targets. Irrespective of the target type it was expected that if the prime instruction was a DO, then more looks should be observed to the animate indirect object relative to looks after a PO prime. The opposite was predicted for PO primes, that is, more looks should be observed on the inanimate direct object. The findings illustrated the predicted patterns in both verb overlap and non-overlap conditions with no interactions for the verb condition (same verb vs. different verb in prime and target), demonstrating general priming effects in three and four-year-olds, but no lexical boost. Thothathiri and Snedeker (2008b) concluded that children extract information from previously acquired associations between verbs and abstract structures.

Still, the question remained open as to whether the absence of a lexical boost effect was due to young age, task type, or the structures tested. Rowland et al. (2012) and Peter et al. (2015) were the first studies that looked at abstract priming with dative structures and lexical boost for verbs across development, rather than in only one age group. Three- to four-year-old and five- to six-year-old children were binned into two age groups to investigate developmental patterns. Both studies did not observe a lexical boost effect in children. Rowland et al. (2012) found immediate structural priming in the different verb and same verb conditions in both age groups. However, the priming effect in the same verb condition was only numerically but not significantly greater than in the different verb condition, yielding no lexical boost effect. Peter et al. (2015) replicated Rowland et al.'s (2012) study by manipulating structural verb bias with four alternating English verbs. The results revealed very similar effects, with no lexical boost in the 3- to 4-year-olds or the 5- to 6-year-olds, but a reliable lexical boost effect in adults.

A lexical boost effect was also not found in Foltz et al. (2015) in a study using the noun modification construction. The authors primed 4- and 5-year-old typically developing German-speaking children and children with SLI with prenominal structures (*der gelbe Ball*

'the yellow ball') or relative clause structures (*der Ball, der gelb ist* 'the ball that's yellow'). All children produced reliably more relative clause responses following relative clause primes than following prenominal primes in both same noun and different noun conditions (with lexical and without lexical overlap). These results were contrary to unpublished findings of Branigan et al. (2004), who also primed English-speaking children with prenominal and relative clause structures (*a blue cat vs. a cat that is blue*) and discovered a lexical boost effect. These diverging results might be attributed to the properties of the languages used.

The lexical boost effect was further found in Branigan and McLean's (2016) study, where the authors looked at passive vs. active immediate priming in children aged 3;5 to 5;0. They found abstract immediate priming effects in the different verb condition —25% in children and 22% in adults—and stronger, verb-specific priming effects in the same-verb condition (45% in children and 55% in adults). This demonstrated a robust lexical boost of 20% in children and 33% in adults, respectively. Furthermore, Morris and Scheepers (2015) (unpublished study available at ResearchGate; dated back to 2009) tested children aged 3;1 to 5;6 using PO vs. DO structures. They found abstract structural priming in the different verb condition (11.2% more POs following a PO prime than a DO prime) and a significantly greater priming effect in the same verb condition compared to the different verb condition (7.9% lexical boost effect)[3]. Interestingly, no age-specific differences in priming strength in either the same or different verb conditions were observed, which pointed towards very similar representational networks in adults and children as early as 3 years of age. Gerard and Keller (2010) found a lexical boost effect with increasing age in a corpus-based analysis of the CHILDES database in 2- to 7-year-old children. It is important to note that the repetition of lexical items between the prime and target involved various word types, rather than being limited to a specific word class like verbs or nouns, as typically seen in traditional priming experiments. Additionally, in a follow-up study, the authors expanded their analysis to include structures that did not always share the same meaning across the two alternative structures. Instead, they rather focused on structural similarity and less on the overall meaning. The study showed more priming with infrequent structures, which was most strongly represented in the lexical overlap condition. Messenger and Hardy (2017) primed 3-

[3] A disadvantage in Morris and Scheeper's (2015) design was the use of eight different ditransitive verbs not equally distributed across the experiment: *give* (36.7%), *show* and *throw* (13,3%), *read* (10.0%), *kick*, *feed* and *pass* (8.3%) and *hit* (1.7%). It is very likely that more frequently occurring verbs during the experiment, such as *give*, might have pushed the lexical boost effect. Another disadvantage was that the experimental pictures were not controlled for directionality of the unfolding event and the items did not contain any fillers. We will turn to this later in the discussion.

to 4-year-olds and adults with PO/DO structures without lexical overlap between prime and target, but importantly, they also included a condition with lexical overlap, comparing repetitions of the same verbs versus the same nouns. They found a significant 3-way interaction between group, priming, and lexical overlap. The results revealed that both children and adults showed a significant lexical boost, with stronger priming in lexical overlap conditions compared to non-overlap (children: 14% vs. 6.5%; adults: 18% vs. 5%). In children, the lexical boost was similar for repeated verbs and nouns (7% vs. 8%), whereas in adults, it was driven entirely by repeated verbs (26% vs. 1%), showing no boost for repeated nouns. These findings stand in direct contrast to Rowland et al. (2012) and Peter et al. (2015), where the 3- to 4-year-olds did not show any indication of more priming for PO/DO structures with repeated verbs. A recent longitudinal study (Kumarage et al., 2022) pointed out very important factors that may contribute to lexically-dependent priming effects in their discussion. The authors tested priming for the active/passive alternation in English in very young children between 3;0 and 4;6 cross-sectionally at four time points: 36, 42, 48 and 54 months. These children showed abstract structural priming and the development of the lexical boost effect across age which appeared to become particularly strong at 48 and 54 months of age, that is, much earlier than reported in other studies. Crucially, this work was the first to demonstrate that certain verbs can affect the priming magnitude depending on whether they occur in the same or different verb condition. The authors used 6 transitive verbs: *carry, chase, hug, kiss, poke* and *push* and found specifically the verb *push* to elicit a priming effect in the same verb condition but no (anti-) priming effect in the different verb condition which behaved very similar across all testing points. For this reason, their results suggested a far earlier developing lexical boost effect compared to the rest of the verbs when *push* was included in the overall analysis. This finding is particularly important with respect to earlier studies on the emergence of the lexical boost effect which find conflicting results about the time point of its development. A corpus analysis of child-directed speech revealed that *push* was used more frequently than the other verbs but was not used in the passive more than the other verbs. The authors concluded that frequent lexical items are more primable, possibly via lexical mechanisms and may have stronger linking to structural alternatives through explicit memory which still requires a concrete explanation. This work reminds us that it is not only the structure itself that may cause a specific magnitude of priming but also the verb which may either boost or decrease the effect depending on frequency of use and the frequency with which it occurs in a particular construction (see Peter et al., 2015). In a recent dissertation, López Lugo (2024) demonstrated a reliable lexically-dependent priming effect for

prepositional phrase attachments (PP) — for example *The girl is touching the dog with the banana* — in English-speaking children's comprehension, but no priming in the lexically-independent condition. This suggests that children have less developed abstract representations than adults and do not yet show a conventional lexical boost, that is, more priming in the lexically-dependent condition compared to the lexically independent condition. However, there was priming when the verb was not repeated across prime and target in Spanish-speaking children. Overall, these results emphasize that different methods, procedures, structures and languages may result in divergent outcomes, making it very difficult to draw conclusions about a general presence or absence of abstract representations and/or lexically specific representations.

Cumulative priming and surprisal: Cumulative priming effects suggest adaptation to the primed structure during repeated presentation and imply that children must implicitly learn structures. As previously mentioned, although several studies have shown that children adapt to presented structures and maintain them for longer periods of time (Gámez & Shimpi, 2016; Huttenlocher et al., 2004; Kidd, 2012a, 2012b; Savage et al., 2003, 2006; Serratrice et al., 2015; Tafuri & Messenger, 2024) such designs did not allow to tap into processing mechanisms of immediate priming effects which have been shown for adults. Priming effects on a trial-by-trial basis have received little attention in the child literature but are a powerful tool to study adaptations effects which mirror more language variability in the input and simulate more every-day interactions. To our knowledge, only two English studies have taken this approach but all primed only passive vs. active structures. Messenger et al., (2011a) used trial number as their cumulative priming predictor in the model. They entered the number of passives and the number of actives previously comprehended and the number of passives and actives previously produced into their model and found no indication of cumulative priming in children. Branigan and McLean (2016) demonstrated cumulative effects under the lenient coding scheme for children, but not for adults. The authors investigated whether 3- to 4-year-old English-speaking children would show immediate priming effects for passives vs. actives either right after the prime or after two intervening utterances (Lag 0 = prime-target vs. Lag 2 =prime-filler-filler-target). They also looked at accumulating priming effects to see whether children's likelihood of producing a passive depended on the amount of previous exposure and as previously reported (see subsection: lexical boost) manipulated the same vs. the different verb condition in prime and target to test whether children are sensitive to long-term frequencies of particular verb-structure pairings. By looking at this manipulation Branigan and McLean (2016) was interested in disentangling several most competitive priming

accounts in the literature (Residual Activation Model, Pickering & Branigan, 1998; ACT-R memory based model, Reitter et al., 2011; error-based implicit learning, Chang et al., 2006). As a task, they used the popular British children's game 'snap', where the experimenter and the child describe pictures to each other in turns. Both children and adults showed abstract as well as lexically dependent priming effects in both Lag 0 (no intervening sentence between prime and target) and Lag 2 (two intervening filler trials between prime and target). No significant interaction between groups was found. When the verb was repeated across trials, children and adults showed enhanced priming effects at Lag 0, but at Lag 2, the effect did not persist anymore. There was evidence that when children are exposed to structures on a trial-by-trial basis, the likelihood of producing a passive increased with increasing number of exposures (cumulative priming effects). In contrast, cumulative priming effects were not found for adults. Another study by Branigan and Messenger (2016) found a higher number of passives produced in session two compared to session one in 3- to 4-year-old children but not in adults. However, in a different study, Messenger (2021) found an increased use of passives in both children and adults after the priming phase compared to a baseline group that received no priming. However, this approach is different from a trial-by-trial analysis. The authors found strong support for implicit learning indicated by both immediate and cumulative priming effects. They also concluded that expected structures yield less adaptation compared to infrequent structures, suggesting surprisal effects. Further, adaptation was also governed by individual experience. Because adults in general possess a weaker learning rate compared to children, the authors concluded that they therefore show less adaptation. A study by Havron et al. (2021) also found a cumulative priming effect in French-speaking children and adults, but they used ambiguous interpretations of the same sentence (verb- vs. noun attachment; *the monkey is tickling the girl with a feather*). It is not clear to what extent studies using syntactic alternating structures can generalize their outcomes to ambiguous structural alternates.

Finally, with regard to *prime surprisal*, we are aware of two studies in children. The first was conducted by Peter et al. (2015) and asked specifically the question whether children are sensitive to immediate prime surprisal as has been previously demonstrated for adults. In their study they used four verbs (*give, show, bring* and *send*), two of which were determined in 12 English-speaking children in the CHILDES database (MacWhinney, 2000) to occur more frequently in a DO structure (*give, show*; 78%-80%) and two were determined to occur more frequently in the PO structure (*bring, send*; 63%-74%). They manipulated structural prime biases either in favor of the PO or DO construction in their trial-by-trial experimental design. They explored whether the priming effect was stronger when the prime verb's bias did

not match the structural option it was presented in (e.g. PO: *Dora gave the rabbit to Boots*) compared to when the verb's bias matched the structure it was presented in (e.g. DO: *Dora gave Boots the rabbit*). As hypothesized, they found stronger priming in the mismatch condition than in the match condition and demonstrated prime surprisal effects which also interacted with age, that is, priming in the mismatch condition decreased across growing age. In the second study, Fazekas et al. (2020) examined whether 5- to 6-year-old English-speaking children and adults learn from prediction errors in dative structures that varied in degrees of predictability as a function of the verb's bias. The authors used a between-subject design containing a pre-test (assessment of initial structural preferences) and a bias phase during which participants were primed with either surprising or predictable sentences, followed by target responses aiming to replicate findings in Peter et al. (2015). Two further post-tests were administered to assess long-term priming effects. While adults showed immediate prime surprisal effects, children were not reliably influenced by surprising vs. predictable prime conditions. Instead, they showed long-term learning in the first post-test, but not in the second one. In contrast to Peter et al. (2015), these results suggest that children adapt to surprising structures in the long run, but not immediately. The authors concluded that further research is necessary to understand the extent to which prediction error contributes to language learning, as other factors may also play a role, such as ceiling effects at pre-test, developmental differences, and syntactic knowledge.

Priming effect magnitude: Some priming studies investigating children vs. adults observed numerically higher priming effects in children compared to adults (Messenger et al., 2011a; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018). Although these studies did not find significant differences, there is ongoing consensus in the literature that children may be more susceptible to learning or adaptation and this can result from greater prime surprisal due to less experience with the language compared to adults. These patterns coincide with other studies claiming that priming is stronger in less skilled language speakers, such as second language learners (Flett, 2006) and aphasics (Hartsuiker & Kolk, 1998). Furthermore, Peter et al. (2015) demonstrated sensitivity to structural verb biases in children as young as 3 to 4 years of age as they were generally influenced by the bias of the target verb. The more a verb was biased towards the DO, the more DOs they produced, and the same pattern held for PO biased verbs. Importantly, this did not interact with the prime suggesting sensitivity to the structural frequencies which these verbs occur in the language. Interestingly, the effect of target verb bias also increased across age and affected adults most. These results suggested a dynamic learning process where the strength of the verb's structural

bias is determined by experience with how often verbs occur in either one or the other structure. Therefore, an accumulation of such experiences may shape our bias preferences across our whole life span.

Priming research in other languages than English: Another potential gap in the child priming literature is that most child priming studies focus on English-speaking populations, which explains only structural processing behavior within the properties of this particular language. To our knowledge, only a handful of studies have looked at priming effects in other languages than English. One study found immediate priming effects and long-term learning in 5-year-old Chinese-speaking children on the SVO-ba alternation (Hsu, 2014). Priming effects for passive vs. active structures have also been demonstrated in Spanish-speaking monolingual children (Gámez et al., 2009; Gámez & Vasilyeva, 2015; Gámez & Shimpi, 2016; López Lugo, 2024) Italian-speaking children (Manetti & Contemori, 2019) and Russian-speaking 5- to 6-year-old children (Vasilyeva and Waterfall, 2012). In the Russian priming study, the authors observed that, differently from English-speaking children, Russian children switched word order from SVO into OVS instead of using a passive construction. Because Russian is a free word-order language, unlike English, the patient can be emphasized in Russian. The authors concluded that children must possess a representation of information structures that is thematically specified (see also Gámez & Vasilyeva, 2015, for similar results in Spanish). There has been also some work in German-speaking children with transitive constructions, pre-and post-nominal adjective structures and subject vs. object relative clauses Brand et al., 2017; Foltz et al., 2015, 2021; Lehmden, 2013), but no work on dative structures.

2.2.3 Priming research in bilingual L2 adults

Most priming research conducted in bilingual adults has focused on cross–language priming (Bernolet et al., 2013; Chen et al., 2013; Hartsuiker & Bernolet, 2015; Hartsuiker & Pickering, 2008; Hartsuiker et al., 2004; Jacob et al., 2017; Kootstra & Doedens, 2016; Loebell & Bock, 2003; Shin & Christianson, 2009). In such studies, participants are presented with a prime sentence in language A (e.g. dative in English – *The man gave the woman a gift* or *The man gave the gift to the woman*) and are asked to produce the target in language B (e.g. dative in Dutch). The goal of cross-language priming studies is to gain clarity on whether and to what extent structures are shared between the two languages spoken by an individual. It is assumed that if a priming effect occurs across two languages, a bilingual's linguistic mind must share structural representations at an abstract level, regardless of the language, given that the same structure exists in both languages. Although the present work does not include

cross-language priming, many of these studies also included a within-language control condition. Therefore, we will also review relevant literature conducted either as a complementary control condition or as a main study on within-language priming in L2 speakers. In within-language priming experiments in L2 speakers, the main research questions in studies involving adults dealt with whether 1) late L2 speakers show abstract priming effects in their second language and 2) if they do prime, do L2 speakers process primes in a different way from monolinguals and 3) whether their real-time structural choices in the L2 are affected by particular linguistic patterns from their L1 not only immediately but also over time. Some research has also dealt with how L2 speakers acquire abstract representations across time (McDonough & Trofimovich, 2009; Shin & Christianson, 2012). The consensus in the literature is that although L2 speakers have much less input in the target language than L1 speakers, and even though the second language was not acquired during childhood, they still exhibit a similar behavior to native speakers if they are proficient enough in their L2 (Kim & McDonough, 2008, 2016; McDonough, 2006; Ruf, 2011; Schoonbaert et al., 2007; Shin & Christianson, 2012). McDonough (2006) primed L2 intermediate to highly proficient English-speaking adults from a variety of L1 backgrounds with PO and DO structures. The results indicated significant priming effects only for the PO structure, but not for the DO. Nevertheless, if participants produced even a single DO response during the baseline, they were more likely to produce DOs during priming than participants who never produced a DO in the baseline. This observation suggests that individuals who do not have a fully acquired abstract representation are unlikely to exhibit structural priming. Kaan and Chun (2018) investigated PO and DO written priming effects in Korean L2 learners of English and American English-speaking adult controls. In American English, the DO is the preferred ditransitive structure, which is different from British English and was exactly the pattern found in the controls in the baseline (57% DO preference). In contrast, the Korean L2 speakers of English exhibited a strong preference for the PO structure (90% PO preference), which is in line with previous findings in L2 learners (McDonough, 2006; Shin & Christianson, 2012). This preference remained largely unchanged when they were primed, resulting in almost no DO responses. Neither group showed significant immediate priming effects. However, the results for cumulative priming effects were triggered by the less frequent option in target language (see *cumulative priming and surprisal* of the same subsection).

The PO production preference in L2 speakers may generally stem from foreign language teaching methods, where learners are typically taught to produce ditransitive PO

forms (e.g., *bring something to someone*, *give something to someone*, and similarly for verbs like *sell*, *send*, *show*, *pass*, etc.). This preference might differ for simultaneous or early successive bilinguals, who may be more sensitive to the target language's verb bias. Another possible explanation is that L2 speakers find it easier to retrieve the equivalent linguistic pattern of the iconic representation of a ditransitive action (i.e., the image of the direction in which the sentence unfolds). For example, a ditransitive sentence which entails an agent, a verb, a theme, and a recipient (e.g., *the girl, give, the ball, the boy)* might be easier to retrieve in a PO construction (e.g., *The girl gives the ball to the boy)* because this sequence corresponds to the sequence of the unfolding action. In contrast, the DO construction would correspond to the iconic representation only until the verb, because the first object is the recipient here, which deviates from typical action sequence.

Shin and Christianson (2012) investigated immediate priming and long-term learning effects in highly proficient L2 English-speaking adults with Korean as the L1. The authors primed their participants with DO structures (The teacher gave the students the book), which were considered as more complex structures, and simple phrasal verb constructions (She picked the book up), which were treated as a structurally simpler form. Importantly, the latter structural option does not exist in Korean. Crucially, they found immediate and long-term priming effects for both structures with the simpler one being the most primable one compared to the syntactically more complex DO structure. The L2 adults showed clearly implicit learning effects that are not affected by their L1, but rather can be affected by structural complexity which may lead to less efficient learning. Gries and Wulff (2005) studied priming behavior of the dative alternation in English L2 speakers whose native language was German. Even though the structural biases were known to be verb dependent and this differed across the two languages (Gries & Stefanowitch, 2004, for English; Schulte im Walde, 2003, for German), the participants showed very similar priming effects in their L2 compared to the native speakers of English. Furthermore, the results provided further evidence that a participant's L2 contains the same probabilistic information as the language system of a native speaker about which verbs are more likely to occur in which construction. A similar question was raised in a within-language priming study conducted by Flett et al. (2013) in which L1 speakers of English and advanced-proficiency L2 speakers of English whose first language was either Spanish or German showed structural priming for both PO and DO dative constructions. The magnitude of this tendency was the same for the L1 and both L2 speaker groups, despite their different L1 backgrounds and the fact that native speakers of Spanish have only experienced a DO in English, because the DO construction

does not exist in Spanish. In addition, the three language groups showed no difference in their tendency to produce DO structures following a baseline condition (intransitive primes). These results therefore suggest that at least at higher levels of proficiency, processing in L2 is unaffected by whether particular structural alternatives exist in a speaker's L1.

Nevertheless, other research suggests that native and non-native representations differ in subtle ways (Clahsen & Felser, 2006), and that L1 can indeed affect L2 processing (e.g., Hartsuiker & Bernolet, 2015; MacWhinney, 2012; Odlin, 1989, 2005). Some studies also show contradictory results regarding the role of L2 proficiency in adults. For instance, Coumel et al. (2024) primed 200 L2 learners of French (with L1 English), analyzing the results by splitting the participants into low and high proficiency groups. When high versus low cognitive load was also taken into account, a significant three-way interaction of proficiency, load and priming suggested decreased priming effects as proficiency increased and more priming as proficiency decreased. These results suggested that low-proficiency speakers may have simply copied the prime sentence throughout the experiment, a finding that was further supported by self-reports from the low-proficiency participants.

Lexical boost effect: There are also some well-established findings on the lexical boost effect in L2-speaking adults (Bernolet et al., 2013; Coumel et al., 2024; Jackson & Ruf, 2017; Kim & McDonough, 2008, 2016; McDonough, 2006; Ruf, 2011; Schoonbaert et al., 2007). However, proficiency modulates the effect here as well. Less proficient speakers show a greater lexical boost than more proficient speakers. Kim and McDonough (2008) showed a lexical boost as well as abstract priming with Korean-English L2 learners. The authors divided their participants into three proficiency-level groups (low, intermediate, high) by using a cloze test. All groups showed more lexically based priming than abstract priming, but this difference was strongest in the low proficiency group. The authors interpreted their results as evidence that L2 speakers rely more on more lexically specific representations. Bernolet et al. (2013) found abstract priming and a lexical boost effect which appeared to be stronger within languages from L2 to L2 (English to English) than across languages from L1 to L2 (Dutch to English). However, only the more proficient L2 speakers showed both abstract priming and the lexical boost effect, whereas the less proficient only showed a lexical boost effect which was larger than that of the more proficient L2 speakers. The authors concluded that only highly proficient bilingual speakers have abstract representations for the *s-genitive* (*the nun her hat; the nun's hat)* that is harder to master than its counterpart the *of-genitive (the hat of the nun*). They also propose that in the lexical repetition condition, participants use their explicit memory of the prime sentence (e.g., *The doctor's hat is green*)

and edit it slightly (e.g., *The nun's hat is green*), which may lead to a very large priming effect. Schoonbaert et al. (2007) also tested L1 Dutch and L2 English participants with the same two priming directions as employed by Bernolet et al. (2013) on dative structures by manipulating the same vs. different verb conditions. The authors found similar priming effects for abstract priming both within and across languages (9% and 8%, respectively) and a lexical boost that was much stronger in the within L2 priming condition (36%) than in the L1 to L2 priming condition (17%). However, Hartsuiker and Bernolet (2017) applied a reanalysis of the data by entering mean proficiency as a continuous predictor into the model. They found similar results to Bernolet et al. (2013) with proficiency being a significant predictor of the priming magnitude; that is, in both studies more proficient speakers showed more priming across languages, and in the within-language condition, priming was stronger for repeated verbs with less proficient speakers. A difference between the two studies occurred in the abstract prime condition within L2: stronger priming with increased proficiency in Bernolet et al. (2013) but stronger priming with less proficient L2 speakers in Schoonbaert et al. (2013). Hartsuiker and Bernolet (2017) suggest that even at abstract levels, low-level L2 speakers use a retrieving strategy of the prime sentence and imitate the sentence with minimal changes.

In sum, the effects in the L2 priming literature suggest that late bilinguals show priming effects both within and across the two languages, but these effects are modulated by proficiency and verb repetition with less proficient speakers showing more priming in the lexical overlap than non-overlap condition. However, more research is necessary in order to obtain clearer results with respect to abstract priming within L2 and the influence of proficiency.

Cumulative priming and surprisal: Mirroring the monolingual adult priming literature, priming literature focusing on L2 speaking adults also finds strong support that structural frequency (or probabilistic structural factors) affect priming magnitude through *prime surprisal* (see Bernolet & Hartsuiker, 2010; Coumel et al., 2022; Gries, 2005; Jaeger & Snider, 2008, 2013; Kaan & Chun, 2018; Kaschak et al., 2011; Scheepers, 2003). This implies that L2 speakers are also aware of structural frequencies in the L2 and can therefore show surprisal effects. With respect to the question of whether structural choice in the L2 is affected by frequency distribution in the L1, research agrees that highly proficient L2 speakers are only minimally affected (e.g., Flett et al., 2013; Ruf, 2011; Shin & Christianson, 2012). Crucially, these results suggest that L2 speakers possess representations for structural biases in their L2 to a similar extent as monolinguals do and may therefore show comparable priming effects at higher proficiency levels.

The priming literature also demonstrated *cumulative priming effects* for both monolingual adults and bilingual L2 speakers (Hartsuiker et al., 2008; Jackson & Ruf, 2017; Kaan & Chun, 2018; Kaschak & Borreggine, 2008; Kaschak et al., 2006, 2011). In a series of online experiments with L2 speakers (Coumel et al., 2022, 2023, 2024), priming effects were also shown not only immediately but also in post-tests for several structures (transitives, genitives and ditransitives) suggesting implicit learning effects across time after exposure to multiple primes. As previously mentioned, the study by Kaan and Chun (2018) did not find immediate priming effects in the Korean L2 speakers of English or in the English-speaking controls. Nonetheless, the authors found a cumulative priming effect related to the number of preceding structures in both groups for structures that were less frequent to the language user. In other words, for every PO encountered (less preferred) by native speakers during the experiment (baseline and priming), the PO production increased, whereas for every DO encountered, the PO production decreased. The Korean speakers showed a similar pattern, however they showed a numerically higher cumulative priming effect for DO structures than for PO structures. Given that the two groups have an initially different strength of representations for the two structures, the results for the cumulative priming effect are in line with the error-based learning account claiming that structural priming is strongest when the structure being processed is unexpected, as well as the base-level learning models (Reitter et al., 2011) claiming that there is a stronger adaptation effect for the infrequent structure. The absence of the immediate priming effect in the L2 group, the authors explained as a lack of the abstract representation of a DO structure (Kim 2010; Mc Donough 2006; Park 2007) in which the first NP (serving as an indirect object) is not robustly represented. When participants expect a PO but get a DO prime instead, they perceive an error signal, but their representations are not strong enough to boost an immediate DO target. However, the activation was strong enough to lead to cumulative priming effects. The authors find support for both earlier mentioned accounts, but not for the Residual Activation Account, and give rise to several questions that need to be studied, such as to what extent are representations of L2 speakers similar or different from L1 speakers and what can proficiency levels tell us about these representations. Crucially, one of the main goals of this experiment was to investigate surprisal effects in L2 speakers based on Peter et al.'s (2015) study, where the authors found prime surprisal effects as well as target verb bias effects in children and adults. In contrast, Kaan and Chun (2018) did not observe any prime verb surprisal effects. Instead, they found target verb bias in both L1- and L2-speaking adults. However, the target verb bias

differed in the two groups according to their initial representation strength, that is, the L1 speakers exhibited the DO bias and the L2 speakers the PO bias accordingly.

Jackson and Hopp (2020) tested fronted (adverb-first) vs. non-fronted adverbial phrases and found larger immediate priming effects in German speakers of L2 English compared to native English speakers but did not find long-term effects within the same L2 speakers in the post-test phase. Although L2 speakers in the study had high proficiency and should have possessed abstract representations for fronted adverbials (since they showed a very strong immediate priming effect), the authors concluded that L2 speakers might not be able to employ these representations in long-term learning strategies. Further, the influence of structural realizations existing in the L1 onto L2 was also investigated from a long-term perspective. For instance, Jackson and Ruf (2017) investigated priming effects in English-German intermediate L2 speaking adults by testing *adverb-verb-subject* vs. *subject-verb-adverb* word orders with temporal (*In winter the grandpa drinks hot chocolate* vs. *The grandpa drinks hot chocolate in winter*) and locative phrases (*In the kitchen the grandpa drinks hot chocolate* vs. *The grandpa drinks hot chocolate in the kitchen*). In German, adverb placement in sentence-initial positions is much more common than in English. Although, adverbs in sentence-initial position are rather infrequent in English, temporal phrases are more likely to occur in sentence-initial position than locative phrases. The authors manipulated prime type to investigate whether structural biases in the L1 can affect structural choices in the L2 and implemented a post-test block in which participants were not primed to address whether priming can lead to implicit learning effects. While there was no impact of preferences in the L1 onto L2 when considering immediate priming effects, the picture flipped when considering long-term and cumulative effects. Because L2 learners of German initially had stronger representations for sentence-initial adverb placement for temporal phrases in English compared to locative phrases, they showed long-term effects in German only for the word order they had a well-established representation for. This was evident in the baseline, where participants produced 20% of temporal phrase initial orders but never produced any sentence-initial orders for locative phrases. In line with previous literature (Kaan & Chun, 2018; McDonough, 2006; Shin & Christianson, 2012), these results illustrate that priming effects can only occur once the abstract representation for a particular structure is fully established. Hence, while these L2 learners had acquired an abstract representation in German for fronted temporal phrases, the fronted constructions for locative phrases were rather lexically-specific at this stage and did not reach abstraction even after a priming phase.

Therefore, it is not evident to what extent and under which circumstances the influence of the L1 on the L2 during structural priming is triggered.

2.2.4 Priming research in bilingual children

While there is some priming research in bilingual L2-speaking adults and a substantially larger number of structural priming studies in monolingual children, relatively little is known about within-language priming effects in early bilingual children. Hence, there is very scarce research on abstract representations in bilingual children, and even less has been studied about how their lexically-specific representations are shaped. Like adult bilingual research, most work on bilingually raised children is dedicated to determining whether bilinguals share abstract structural representations across the two languages (see Gámez et al., 2022, for a recent review). These studies show cross-linguistic priming effects where children were primed from language A into language B and in the opposite direction (Gámez & Vasilyeva, 2020; Kootstra & Unsworth, in prep.; Unsworth, 2023; Vasilyeva et al., 2010; Wesierska et al., 2025; Wolleb, 2015; Wolleb et al., 2018), suggesting cross-linguistic activation of both language systems at a purely structural level. However, given the limited number of studies on cross-language priming effects, many questions are still open, such as whether cross-language priming is bidirectional and whether the magnitude of priming effects is comparable to within-language priming. In line with cross-language adult research, some of these studies contained a within-language control experiment. For instance, Wolleb et al. (2018) tested 38 bilingual Norwegian-English speaking children (aged 4;7 to 8;5) both across languages (primed from English to Norwegian) and within Norwegian on the dative alternation in production and found similar priming effects in within-language and cross-language priming. The authors analyzed their children as one age group although the age differences were rather large compared to most child priming studies. The children demonstrated higher scores on the vocabulary test in English than in Norwegian, although they all lived in Norway. These children had at least one Norwegian-speaking parent and were recruited from international schools with English used as the main language. In another study, Wolleb (2015) primed word order differences in possessive constructions from English to Norwegian and within Norwegian (aged 4;5 to 8;5). In English, only the pre-nominal word order is possible (*my car*), but in Norwegian both the pre-nominal and the post-nominal (*car-my*) is possible depending on pragmatics/context). Wolleb used a blocked design and primed children with pre-nominal primes either in an English block or in a Norwegian block. She hypothesized that the priming effect should be stronger for those contexts where the two languages converge.

Consistent with the predictions, the study observed cross-language priming effects in both contexts, with stronger priming when the prime and target matched in word order. The priming effects were particularly pronounced in the within-language Norwegian condition. Interestingly, a control group of monolingual Norwegian children showed no significant difference in priming effects compared to the bilingual children in the within-language condition.

Unsworth (2023) conducted a similar study with two groups of bilinguals, focusing on the genitive construction. She carefully selected her experimental bilingual groups – Spanish-Dutch and English-Dutch, along with monolingual Dutch controls – based on the structural frequencies of the genitive construction in the languages they spoke. She used a blocked design containing a priming phase and a post-test phase (no primes) and investigated cross-linguistic influence in bilingual children both across and within languages. She hypothesized that if syntactic representations are shared between languages, this should also be evident within each individual language. Therefore, priming effects would likely be influenced by proficiency, as discussed in Hartsuiker and Bernolet's (2017) priming account discussed in Section 2.3. In her first experiment, she primed children from English into Dutch with blocks of either pre-nominal or post-nominal genitive (*the farmer's dog* vs. *the dog of the farmer*) and found inverse-frequency effects across languages where the strongly dispreferred pre-nominal constructions in Dutch was produced more often after being primed with the more frequent pre-nominal construction in English. In the second experiment, Unsworth added Spanish-Dutch-speaking children and Dutch-speaking monolingual children and primed all three groups within Dutch. She hypothesized that the Spanish-Dutch bilinguals should show the highest priming effect within Dutch due to inverse frequency effects because the prenominal structure does not exist in Spanish and is highly dispreferred in Dutch. The English-Dutch children on the other hand, should show the least priming effect in Dutch due to more frequent use of pre-nominals across the two languages, whereas the monolingual Dutch-speaking children should fall somewhere in between. Within Dutch, all three groups showed priming for pre-nominals when primed with pre-nominal constructions compared to the post-nominal condition. However, in the post-test phase Spanish-Dutch children did not produce any pre-nominal structures whereas the other groups showed a gradual decrease of priming effects across the post-test block. When there was no pre-nominal prime (unexpected) in the post-test or post-nominal primes in the priming block, the children turned quickly to their default post-nominal constructions which is the only option in Spanish. Trial number was also taken into account in analyzing data from the within-language priming

sessions to investigate possible cumulative priming. All three groups showed a gradual decrease of prenominal constructions during the priming phase. However a significant interaction of group, trial and phase revealed that the Spanish-Dutch group produced more pre-nominal constructions at the beginning of the priming phase than the other groups, but their use declined more rapidly with increasing trial number. Unsworth explained this effect as cross-linguistic influence from Spanish by using Chang's (2002, 2006) error-based learning theory, which postulates that priming magnitude is expected to be higher the more unexpected the prime structure is, and that for subsequent primes internal adjustments to our language system will depend on the size of expectancy. Contrary to the expectations, the English-Dutch children did not differ from the Dutch monolingual group, suggesting a native-like behavior within Dutch with little or no influence from English. Interestingly, priming effect size was modulated by proficiency in the heritage languages (English and Spanish) with stronger cross-language priming with increasing proficiency, whereas in the within-language condition there was no effect of proficiency on the priming magnitude. Instead, proficiency was more associated with the likelihood of producing the most frequent structure or only structure available in the heritage languages. In sum, the results indicated clear cross-linguistic influence from the heritage language into Dutch in the cross-language condition and rather subtle but still detectable cross-language effects in the within-language condition. In another study, Kootstra and Unsworth (in prep.) primed 36 Dutch-English and 34 Dutch-German bilingual children within Dutch in comprehension-to-production priming. The age range chosen in their study (7- to 10-year-old bilinguals, M = 8.96; SD = 1.21) included rather old children compared to age ranges reported in most monolingual child priming studies. All children were raised either from birth with both languages or were exposed to both languages before age four. All children showed priming effects of ambiguous PP-attachments such as *The granny catches the farmer with the bucket* in which the prepositional phrase *with the bucket* can either be attached to the actor (the granny has the bucket) or to the patient (the farmer has the bucket). In other words, when the prime sentence was presented in the patient attention condition, the target picture was more likely to be described by a patient attention interpretation.

Lexical boost: There are no published findings with respect to the lexical boost effect in early second language acquisition. Only Kootstra and Unsworth (in prep.) implemented a condition in which the verb between prime and target was the same to test for a *lexical boost effect*. They found a lexical boost effect not only during immediate priming but also, in contrast to a vast number of studies showing that the lexical boost effect is short-lived

(Branigan et al., 1999; Hartsuiker et al., 2008), they demonstrated the persistence of a lexical boost in post-tests. This is the first demonstration of a long-term lexical boost effect in children and is also the first study to show a lexical boost in bilingual children within one of the two languages spoken. Because there is no other research we know of that tested the lexical boost effect within one language in bilingual children, we can only derive indirect comparisons from monolingual adult research (Hartsuiker et al., 2008; Pickering & Branigan, 1998; Schoonbaert et al., 2007), some adult bilingual research (Kim & McDonough, 2008, 2016; McDonough, 2006; Ruf, 2011; Schoonbaert et al., 2007; Shin & Christianson, 2012) and a handful of studies in monolingual children which show conflicting results on the emergence of the lexical boost. All these studies were discussed in Section 2.2. Specifically in children, some studies show stronger priming when the lexical head is repeated (Branigan & McLean, 2016; Branigan et al., 2005; Messenger & Hardy, 2017; Morris & Scheepers, 2015) while others do not (Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008b). In addition, Rowland et al. (2012) and Peter et al. (2015) found a numerical trend towards increased priming when the verb is repeated between prime and target suggesting a developmental effect. Hence, since Kootstra and Unsworth (in prep.) is the only study which tested the lexical boost in bilingually-raised children, it is not clear when the lexical boost effect emerges and whether it also occurs around the same age with other structures and other languages.

Cumulative priming and surprisal: There is almost no literature on *cumulative priming*, *long-term priming effects*, or *surprisal effects* for bilingual children tested within one language. Regarding long-term effects, Unsworth (2023) reported no findings in the post-test phase for English-Dutch speaking bilinguals across languages and within Dutch for the Spanish-Dutch bilinguals. However, there were post-test effects in the English-Dutch and the monolingual Dutch groups. Importantly, Unsworth (2023) is the only study we know of who investigated cumulative priming effects with increasing trial number during the priming block. She found a gradual diminishment of priming with increasing trial number which was strongest in the Spanish-Dutch children whose heritage language Spanish did not contain the primed construction. Although the author attributed this to structural frequency effects in the heritage language, which may influence the persistence depending on the extent of prime surprisal for follow-up trials, this effect is rather surprising and shows the reversed pattern of the cumulative priming effect broadly reported in adult and some child literature (see subsections 2.2.1, 2.2.2, 2.2.3). It is therefore not evident whether the same effect would occur within other languages or other structures. Another effect from her study indicates a

role for surprisal: there was more priming in the Spanish-Dutch children than in the English-Dutch children and the monolingual Dutch speaking controls, but the priming magnitude between the latter two groups did not differ although English speakers prefer the pre-nominal over the post-nominal structure. According to Unsworth's hypotheses, the English-Dutch group should have shown the least priming effect due to more pre-nominal exposure from the heritage language, while in Dutch the prenominal construction is highly dispreferred. This result demonstrates subtle frequency effects causing surprisal from the heritage language that has no structural alternate, but the heritage language having both structures does not necessarily affect structural preferences in the other language. These results further demonstrate that the bilingual child literature needs more research in order to better understand surprisal and cumulative priming effects. The rest of the bilingual child studies rather investigated persistence or long-term effects by using post-tests. Kootstra and Unsworth (in prep.) reported a frequency effect that persisted for some time. During the baseline, children preferred the actor attention interpretation and showed stronger immediate priming effects for the less preferred patient attention interpretation. These effects persisted over a post-test directly after the priming session and two weeks later in a follow up post-test suggesting *long-term priming* effects. Similar effects occurred when primed from English to Dutch; however, all effects turned out to be weaker compared to the within-Dutch condition.

The only study we know of that specifically focused on within-language priming effects in L2-speaking children was conducted by Gámez and Vasilyeva (2015). The authors tested 5- to 6-year-old Spanish-speaking L2 learners of English (N=14) in a kindergarten classroom setting who were exposed to English daily for 30-45 minutes. Their research question primarily addressed whether brief input manipulations can increase the use of complex syntactic structures such as passives versus actives. First, children were asked to describe transitive scenes, but due to very poor knowledge of the L2, they produced only 34 complete responses out of 140 possible (24%), with 19 actives and no passives. Children were then divided into four groups and primed with either active or passive structures, with or without repetition of the prime sentence. Exposure to passive primes led to some passive production, whereas active primes did not increase active use. However, repetition of the experimenter's sentences strengthened the production and comprehension of both passives and actives. In comparison, monolingual 4- to 5-year-old children in Huttenlocher et al. (2004) did not show the benefits of repetition. These outcomes show that even at very low proficiency levels, priming can strengthen structural use of advanced syntactic forms in production and comprehension. It is worth noting that while Spanish does have a passive form

(the fue-passive), it is very limited in use and is much less likely to be used by Spanish-speaking children compared to English-speaking children. The priming results therefore suggest that L2 priming can occur irrespective of whether a particular construction is present in the L1. Importantly, these children had a very low proficiency level in the target language and a blocked testing procedure which is not directly comparable to traditional priming studies with bilingual children and the research questions that are tested in the present work

2.2.5 Identifying the gaps in the priming literature

The literature on priming research has significantly expanded our understanding of structural processing in both children and adults. Since the priming literature predominantly focused on adults – and these findings have served as a foundation for studying children – there is still a lack of fine-grained research in early acquisition and most importantly a developmental approach to study abstract representations, lexically-dependent priming effects (lexical boost), surprisal as well as cumulative effects. Importantly, bilingual child research within each of the two languages spoken by the child is extremely limited and deserves solid attention in the priming literature.

With respect to monolingual children, abstract representations emerge as early as age three, but it remains unclear whether priming effects change with development. Further, some studies report numerically stronger effects in younger children than in older children or adults, possibly due to greater surprisal or increased learning rates (Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018). However, because these observations are numerical rather than statistically significant, further research is necessary to determine whether such differences are robust. Most studies also lack baselines for initial structural preferences, which are essential for interpreting the priming direction. Testing languages that have a strong structural preference over another (e.g., German datives) may elicit stronger priming effects due to greater surprisal and help reveal developmental differences.

The lexical boost effect also requires a developmental approach, as findings are inconsistent across studies. Some studies report a lexical boost effect in children (Branigan & McLean, 2016; Branigan et al., 2004; López Lugo, 2024) and others do not (Foltz et al., 2015; Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008b). One possibility is that the lexical boost effect develops with increasing age and is not observed in younger children (see Gerard & Keller, 2010; Kumarage et al., 2022). An alternative possibility is that some verbs are more primable than others depending on frequency of use, both individually

and the broader population (see Kumarage et al., 2022; Peter et al., 2015). If true, the overall bias for particular structures (whether structure A is much more frequently used than structure B) may reveal different outcomes compared to structures with weak biases (e.g. datives in English). Further, language typology may also influence priming outcomes. For instance, German-speaking children showed priming for relative clauses (Brand et al., 2017), whereas Italian-speaking children did not (Manetti & Contemori, 2019). These findings underscore the need to examine languages beyond English, which dominates the literature (Foltz, 2022). Notably, Priming of the German dative construction has not yet been studied in German-speaking children, despite its clear contrast to English in structural biases. The double-object (DO) construction is the most preferred dative realization in the German population whereas the prepositional object (PO) structure is used relatively infrequently – and extremely rarely by children. Such contrasts will allow us to examine whether and to which extent a strong structural bias in the language affects structural priming. This contrast across structural biases is relevant for both monolingually- and bilingually-raised children (who receive less German input than their monolingual peers) and allows us to study how strong structural biases affect priming, including lexically-dependent vs. lexically-independent effects, surprisal, and cumulative learning. Research on cumulative priming on a trial-by-trial basis has only been conducted in a handful of monolingual child studies and shows mixed results (Branigan & McLean, 2016; Messenger et al., 2011a; Unsworth, 2023), highlighting the need for further developmental studies.

With respect to bilingually-raised children, no studies to date have investigated abstract representations within one language in very young children through priming (aged 3;0 to 4;5). As opposed to a vast amount of priming research showing early abstract representations in monolingual children, it is not clear whether bilingually-raised children already show abstract representations as young as three years of age. The available literature on priming effects in bilingual children focused mainly on cross-language priming effects and occasionally included a within-language priming condition, but importantly with older children (Unsworth, 2023; Wolleb, 2015; Wolleb et al., 2018). Further, the lexical boost effect, surprisal, and cumulative effects remain understudied.

Although cross-linguistic influence during priming is well documented in bilingual adults, the structural options and biases of each language in bilingual children have received little attention during language priming. In adult L2 speakers, there is a growing consensus that structural options in L2 are mostly unaffected by structural options in L1 at high proficiency levels (Flett et al., 2013; Gries & Wulf, 2005; Shin & Christianson, 2012). However,

Unsworth (2023) was the first to examine inverse frequency in within- and cross-language priming among bilingual children and monolinguals, finding that inherited frequencies influence within-language priming, consistent with some work in adults (Jackson & Ruf, 2017). Although these effects were subtle, they suggest that the frequency of a structure—and whether an alternative exists in the other language can matter for bilingual priming. Research with adult L2 speakers has also shown that the extent to which bilinguals exhibit priming is closely related to their language proficiency in the L2, reflecting the gradual emergence of abstract syntactic representations. While lexically-dependent priming is present even at low proficiency levels, abstract (lexically-independent) priming emerges with growing proficiency when an abstract representation for the primed structure exists in the mental language system (Kim & McDonough, 2008, 2016; McDonough, 2006; Ruf, 2011; Shin & Christianson, 2012). Given that bilingual adults show priming effects despite late acquisition and reduced exposure, we expect early bilingual children to also show abstract (lexically-independent) priming effects, provided they possess an abstract representation in the target language. However, the development of the lexical boost effect is less clear. Monolingually-raised adults and late L2 speakers exhibit lexical boost effects, but monolingually-raised children show mixed results. If the lexical boost is developmentally driven, bilingual children may mirror similar outcomes to monolingually-raised children. If the lexical boost reflects deeper aspects of linguistic architecture, bilingual children may differ from monolinguals. The only study directly comparing lexically-independent and lexically-dependent priming in bilingual children is currently in preparation by Kootstra and Unsworth. The authors found priming effects in the lexically-independent condition, suggesting the presence of abstract representations and a lexical boost effect in bilingual children. However, their participants were relatively old and also spanned a wide age range (7–10 years) compared to most child priming studies, making it unclear when these effects first emerge and how they develop at specific ages within this range. Finally, bilingual children's priming behavior with respect to surprisal and cumulative effects may only resemble those of monolinguals if bilingual children are sensitive to the structural bias of the target language. If not, their priming patterns might differ substantially. In sum, while priming research has deepened our knowledge on processing structures in adults and to a certain extent also in children, key gaps remain regarding developmental trajectories and bilingual processing. Addressing how structural representations evolve, interact, and generalize across languages and frequencies will help build a more comprehensive model of structural priming across development.

2.3. Modelling the mechanisms of syntactic priming

Structural priming provides insights into how our mind learns and remembers syntactic patterns and is closely related to language acquisition. Two main theories in the priming literature provide the most convincing approaches to understanding the mechanisms operating during priming - the *Residual Activation Account* (Cleland & Pickering, 2003; Pickering & Branigan, 1998) and the *Implicit Learning Account* (e.g. Bock & Griffin, 2000; Chang et al., 2006, 2012). These accounts arose on the basis of adult behavioural observations and both theories find strong support in the literature. However, the Implicit Learning Account has been extended most successfully to child processing. In the following subsections, we will introduce each of the accounts in more detail and expand our discussion to possible accounts of priming in bilingual speakers.

Another relevant model – the ACT-R model developed by Reitter et al. (2011) which integrates elements of both the Implicit Learning and Residual Activation models but is primarily grounded on memory-based processing accounts. This model will also be discussed, given the substantial support it has received in the recent literature.

2.3.1 Implicit Learning Account

According to the *Implicit Learning Account*, priming is a continuous procedure which strengthens the linking of a syntactic representation throughout the lifespan blts and children continuously refine their ability to map message-level meanings onto abstract syntactic representations. This process involves both strengthening frequently encountered structures and adapting to novel or less familiar constructions. Through varying input over time, speakers expand, adjust, or even overwrite their established mental representation to accommodate new structural patterns. This refining process is driven by an error-based learning mechanism as proposed by the connectionist framework (Chang et al., 2006) and is further complemented by the Dual Path Model (see Chang, 2002). The Dual Path Model represents two pathways: a meaning system and a sequencing system. The meaning system captures more semantic information of the intended message containing thematic roles (e.g., agent, patient, recipient), lexical-semantic information (e.g., verb meaning, arguments) and conceptual features that are relevant for the creation of a message. The sequencing system is a simple recurrent network that helps to sequence the message in a syntactically appropriate way and has only limited contact with the meaning system. The sequencing pathway learns over time how to produce structures that conform to the message. The sequencing system uses statistics (frequencies of co-occurring items) to generate a prediction about the next word

based on sequential restraints (the previous word) and the meaning network (type of message). Since production and acquisition is based on comprehension, the model learns to produce by listening, that is, we predict output words on a word-by-word sequence at each point gradually while we perceive an incoming sentence. During this process, a predicted word and the word heard in real-time pass through a hidden layer that interacts with contextual memory of earlier parts, allowing the system to learn long-distance dependencies. In this way, our individual expectations are shaped by the representational networks we have built through experience. In other words, we draw on the distributional regularities in language that we have acquired up until the point we encounter new linguistic input. Any mismatch—referred to as an "error"—between the prime sentence and our internal expectations creates a subtle bias toward producing a similar structure. Specifically, when the dual-path model predicts the sequence of the input sentence while processing syntactic alternations, the "choice point" in the sentence becomes crucial. This is the point at which a syntactic alternative is specified. For instance, in a double-object vs. prepositional object dative structure, the critical choice point appears right after the main verb on the noun phrase, as in *The man **sends** the package to the client/ the client the package*, which is either the recipient in a DO structure or the theme in an alternative PO structure. If the DO structure is the rarer variant, its higher prediction error should increase the likelihood of reproducing it compared to the alternative PO structure. But if the DO is relatively frequent, the prediction error will be small, and the priming effect may be weak or absent. Depending on the language's structural bias and the individual's preference for one structure over the other, the processor calculates the difference (error strength) between the predicted and actual constructions and makes gradual adjustments to the weights of our syntactic knowledge, resulting in improved predictive abilities over time. The stronger the error between what we hear and what we predict, the stronger the priming effect; this is known as *prime surprisal* or *inverse frequency* effect (Jaeger & Snider, 2008, 2013). Similarly, the model also learns about structural verb biases and may show different priming effects depending on the structural frequencies in the input associated with a particular verb (e.g., the verb *give* is more biased towards a DO construction than the verb *send*). These processes help to develop abstract syntactic categories together with their meaning. Importantly, according to Chang et al.'s (2006) model, younger children should experience more surprisal and show increased priming effects compared to older peers due to less experience with the language and consequently less stable representations that are much more vulnerable to change. This aligns well with greater numerical trends in priming magnitude previously reported in children (see Section

2.2.2; Messenger et al., 2011a; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018). Our internal language system is constantly shaping our internal weighting system from childhood up to adulthood by incoming input from our language environment which leads to long-term implicit learning. For instance, when our processing system is systematically encountering DO sentences as previously illustrated (e.g., in an experimental session), we tend to adjust this structure more often which results in long-term adaptation effects or so-called *cumulative effects* (Jaeger & Snider, 2008, 2013). Importantly, cumulative priming is more likely to occur with less predictable or less frequent structures, leading to adjustments in the internal weighting system. As a result, speakers may begin to produce the rarer alternative significantly more often (for example, across trials in an experimental session or in a post-test after the priming session) than they would have before exposure. Hence, structural priming can lead to lasting changes due to gradual adjustment and accumulation of structural input. Given that children are in an active phase of language acquisition and are generally more sensitive to input due to heightened learning demands, they are expected to exhibit stronger and more persistent long-term priming effects compared to adults. These effects may reflect not only momentary facilitation but also incremental learning and adaptation of syntactic knowledge over time.

According to Chang et al.'s (2006) Dual Path Model, lexical and thematic information is represented separately from abstract syntactic representations. As a result, there is no internal mechanism within the architecture that can boost priming when lexical items are shared between prime and target. As previously mentioned, the model possesses knowledge about verb-structure biases based on distributional input and identifies how often certain verbs occur with particular syntactic structures. The more often a verb is used in a particular construction, the more the model strengthens the association between these verb-structure constituents through error-based learning. Consequently, if the learning rate is high or if sufficient exposure occurs (e.g., during an experiment), these verb-structure associations can be updated more rapidly and result in persistence beyond the immediate trial. This accumulation gives rise to longer-lasting increases in the likelihood of producing the same verb–structure combination, an effect that can be associated with a long-term lexical boost, even though it arises from gradual adjustments in verb bias rather than from a dedicated lexical boosting mechanism (see Section 2.3.2 for details). Given that a lexical boost effect has been reported in the literature to be short-lived, Chang et al. (2006) proposed that the lexical boost that emerges during syntactic priming may not derive from structural priming mechanisms: "We hypothesize that lexical enhancement of priming is not due to the weight-change mechanisms

that lead to long-lasting structural priming. Rather, they are due to explicit memory for the wording of the prime. When the target is being planned, the repeated content word serves as a cue to the memory of the prime and this biases the speaker to repeat its structure. This explicit memory component to priming is distinct from the model's weight-change mechanism." (p. 275). The lexical boost effect has not been consistently observed in children, with some studies failing to find evidence for it. This variability presents a challenge for theories that attribute the lexical boost to transient activation of lexical items, as such mechanisms would predict its presence regardless of age. In contrast, Chang et al.'s (2006) implicit learning theory offers a compelling explanation for the developmental trajectory of the lexical boost since children can plausibly be expected to have less memory capacity at younger ages, and then an increase in memory capacity with an increase in age.

2.3.2 The Residual Activation Account

Pickering and Branigan's (1998) Residual Activation account is a lexicalist account of priming that arose based on Roelofs' (1992) model of lexical access in production. In this model, lemma nodes are connected to lexical concepts and word forms, as well to combinatorial nodes that encode syntactic information. These nodes are activated when a particular syntactic pattern is encountered. For instance, when the speaker listens to a PO structure, such as *The girl is bringing the ball to the boy*, the processor will activate the verb *bring* and the corresponding argument structure (stored in a combinatorial node) that this verb can occur in. Importantly, the activation of the recently encountered PO structure will lead to stronger activation of that node. If the speaker intends to produce a new sentence with a dative structure, the PO node will stay active and bias the speaker to use the same structure. This effect is boosted when the speaker wishes to use the same verb (here, *bring*) again because the verb and its combinatorial node are both active. The Residual Activation account is able to explain both abstract priming and increased priming when lexical content is shared (lexical boost) with the same mechanism. However, structures are activated for a short period of time irrespective of whether lexical items are shared or not. That is, both abstract priming effects and the lexical boost effects diminish shortly after priming, but because the verb is activated repeatedly, the activation is stronger and results in a lexical boost. Therefore, this account has difficulties explaining long-term effects and structural biases. Furthermore, the Residual Activation account struggles to explain why some child studies did find a lexical boost effect and other studies did not. Since this account predicts the lexical boost effect through short-term activation of lexically-syntactic connections, it assumes that enhanced

priming should occur whenever lexical overlap is present in prime and target. However, inconsistent findings in the child research suggest that other factors may play a role, such as developmental patterns in memory capacity or processing efficiency.

Based on these divergencies, children's results fit better with an account according to which the lexical boost is a function of explicit memory which improves with development. Interestingly, Scheepers et al. (2017) found a so called *cumulative lexical boost effect* assuming that the more content words (constituents) in the sentence are shared across prime and target, the bigger the lexical boost effect becomes. This provides support for Chang et al.'s (2006) theory claiming that repeated content words serve as retrieval cues and extract the structure the content word appeared in leading to structural reproduction. Importantly, experiment 3 in Scheepers et al.'s (2017) study showed that it is not the order of the constituents that cause the increase in the structural adaptation, but the number of content words repeated, that is, irrespective of where in sentence the word appeared. This provides a strong argument against the Residual Activation Account. These findings also speak against the notion of lexically-specific representations that has been widely proposed in the literature, especially for children. Nevertheless, the authors do not try to argue against the existence of lexically specific syntactic frames triggered by the lexical head. Instead, they treat their results with caution suggesting that short-term lexical boost effects may not stem from structural representation, but rather reflect explicit memory retrieval outcomes.

2.3.3 The ACT-R memory-based model

The ACT-R Model (Reitter et al., 2011) is grounded on memory-based accounts of language processing and also offers an explanation for several key effects in structural priming – including abstract (lexically-independent) priming effects, the lexical boost effect, surprisal, and long-term priming effects by using memory retrieval mechanisms. In this model, abstract priming reflects a learning process as a consequence of spreading structural activation at base-level and activation within long-term memory, where syntactic structures are represented as chunks. The syntactic chunks that were recently retrieved are more active (higher base-level activation), resulting in easier retrieval with a higher probability of being re-used. Recently retrieved activations are less likely to decay and are hypothesized to lead to long-term priming effects because they accumulate with exposure. Reitter et al. (2011) propose that the lexical boost effect emerges as a function of the activation of lexical entries in working memory and spreading activation of the primed structure in the syntactic chunk in long-term memory. Because lexical information in working memory is captured temporarily,

the lexical boost effect can only be short-lived. However, similar to the residual activation account, this model cannot explain the absence of the lexical boost effect in children. Additionally, this model cannot account for the cumulative priming effects observed in children but not in adults, as demonstrated by Branigan and McLean (2016). In contrast, Chang et al.'s (2006) Implicit Learning Model explains these results through differences in learning rates, based on the architecture of the implemented Dual Path Model . Children with weaker representations are more prone to learning, while adults with slower learning rates may also show cumulative priming effects after prolonged exposure or when the structural alternative is less common or less entrenched in their minds, leading to greater surprisal. In general, the ACT-R Model predicts no difference between children and adults in the magnitude of either immediate priming effects or the lexical boost effect.

2.3.4 Contrasting priming models based on developmental data

All three models – the Implicit Learning Account, the Residual Activation Account and the ACT-R Model – have contributed immensely to our understanding of how structural processing may work in our mind. However, based on the assumption that linguistic representations are not static (but dynamic) in both children and adults, specifically the Implicit Learning Model not only accounts for mechanisms responsible for priming, but also accounts for the very early stages of language acquisition and its development. In contrast to lexicalist accounts such as Residual Activation which are based on structural spreading activation among lemma and combinatorial syntactic nodes, the Implicit Learning Account explains priming as error-based adaptation to structural input while we predict upcoming sentences word-by-word. By taking structural frequencies into account, this theory predicts surprisal for low-frequency structures, long-term and cumulative priming effects, which have been found in both children and adults. Although the Residual Activation Model has been one of the most prominent accounts for explaining adult language processing and was successfully extended to L2 processing as well as cross-language processing (Hartsuiker & Bernolet, 2017; Hartsuiker et al., 2004; Schoonbaert et al., 2007), it has struggled to explain frequency effects, which may cause increased priming effects on an abstract level, and most importantly, the absence of a lexical boost effect in children. While the Implicit Learning Model assumes a separation of lexical and thematic information from syntactic representations, the Residual Activation Account assumes that linguistic input is processed at an integrated lexically-syntactic level. Both models assume that an existing syntactic representation is activated, but they differ in whether activation is transient or longer-lasting and differ in the kind of network

that is proposed. The Residual Activation Model holds that activation of combinatorial nodes is short-lived and decays rapidly, leading to a generally limited duration of priming, with the lexical boost effect decaying the fastest. Interestingly, Scheepers et al. (2017) found a so-called *cumulative lexical boost effect,* assuming that the more content words (constituents) in the sentence are shared across prime and target (irrespective of their position in the sentence), the stronger the lexical boost effect becomes. This supports Chang et al.'s (2006) theory claiming that repeated content words serve as retrieval cues for structural reproduction. These findings also speak against lexically-specific representations reported in children (Tomasello, 2000, 2003). Although the authors treat their results with caution, they suggest that short-term lexical boost effects may not stem from structural representations but rather reflect explicit memory retrieval, a pattern consistent with Chang et al.'s (2006) model. On the other hand, the explanation of the lexical boost effect by the Implicit Learning Account is not as convincing as the Residual Activation theory. Both models account for the influence of language change.

Similar to the Residual Activation Model, the ACT-R Model also faces difficulties in explaining the absence of a lexical boost effect in children. Both models attribute the lexical boost to temporary activation—whether through residual activation or memory retrieval cues—which should be present regardless of age, provided there is lexical overlap. The absence of lexical boost effects in younger children suggests that developmental factors, such as limited working memory capacity or immature lexico-syntactic representations, may play a larger role. Additionally, the ACT-R Model does not offer a satisfactory explanation for cumulative priming effects that have been observed in children but not in adults (see Branigan and McLean, 2016). These trial-by-trial learning effects suggest a more dynamic age-dependent adaptation process, something that is outside the explanatory domain of the ACT-R Model's decay and retrieval-based mechanisms. These limitations raise questions about both model's abilities to fully capture developmental changes in syntactic processing and learning.

2.3.5 Accounts of Structural Priming in Bilinguals

Several accounts have been proposed to explain structural representations in bilingual adults. However, most of them focus on between-language priming and mainly differ in whether syntax is fully shared across multiple languages, or partially shared in that separate language systems interact with each other. Although these accounts are not directly applicable to the priming studies reported in this dissertation, they nonetheless imply that if between-

language priming is possible, within-language priming should be not only possible but potentially more robust. For these reasons, we will briefly introduce these accounts.

The *Shared Syntax Account* predicts that syntax is shared among multiple languages, and the more similarity across structures, the more priming occurs. For instance, Hartsuiker et al.'s (2004) Lexicalist Shared Syntax Account, which is an extension of Pickering and Branigan's (1998) monolingual processing model, suggests that lexical representations of words are connected to corresponding structures and concepts that occur together in the language. For example, a verb such as *give* would be connected to either a prepositional dative (e.g., *the flower to the girl)* or a double object dative (e.g., *the girl the flower),* storing a combinatorial node for each structure. Thus, one or the other of these combinatorial nodes would become active not only when producing or comprehending in one language, but also in the other languages spoken by the individual. In an extended version of this account, Hartsuiker and Bernolet (2017) proposed a developmental trajectory of merging representations. The previous model refers to the end state of the acquisition processes of both languages, whereas the extended model addresses the levels in the very first stages of the language acquisition process. L2 learners may start out with specific lexical entries that are not yet linked to any structures, and stages across the acquisition process then depend on individual experiences and formation processes. This account assumes that at early acquisition stages, individuals start out with separate structural representations for individual languages, allowing within-language priming. At later stages of language acquisition, these merge into a single representation, ultimately allowing for the full sharing of structures and consequently enabling between-language priming.

A *Partial Sharing View* suggests separate storage of syntactic representations for each language but an interaction between them. This account was proposed by Kantola and Van Gompel (2011) who suggested that lexical representations are stored separately, but that the syntactic representations are shared, even though separate combinatorial nodes would exist for each language. Based on the outcomes of their priming studies, the authors report that between-language priming and within-language priming are similar in magnitude, given that language proficiency is high. Individuals with lower language proficiency show weaker between-language priming than within-language priming. These results indicate that shared syntax across languages may occur when nodes are sufficiently connected across languages with better proficiency. Therefore, Kantola and Van Gompel's (2011) findings are consistent with the shared syntax account in that shared combinatorial nodes interact during between-language priming in skilled speakers. Importantly, their account predicts between-language

priming only when the primed structures exist in both languages. Otherwise, the priming effect is either very small or absent. A similar account was proposed by De Bot (1992) in the *Bilingual Production Model* (BPM), a bilingual extension of Levelt's (1989) speech production model. The model postulates that the lexicon is shared between production and comprehension, and that conceptual and lexical processing is similar in L1 and L2. In contrast, the syntactic processes of formulating a sentence are separate in the two languages, but can prime each other depending on the similarity between languages and the proficiency level of a speaker. In other words, the more alike language systems are, the more cross-linguistic impact can occur, and the higher the speaker's proficiency in the L2 is, the better a speaker can separate the two languages and the less cross-linguistic influence is likely to occur. Importantly, either the Shared Syntax Account or the Partial Sharing View would both predict within-language priming in bilinguals if an abstract representation exists for the primed structure. However, there is no clear consensus on how such effects are shaped by factors such as structural frequency, long-term vs. short-term priming effects, lexical repetition and other related factors.

There have been also attempts in the literature to extend the Implicit Learning Model to bilingual processing (Khoe et al., 2023; Tsoukala, 2021), but again, more for cross-language priming than for within-language priming. It is therefore not clear how the Implicit Learning Model would capture within-language priming effects in bilingual speakers, particularly in bilingual children, given that originally the model was developed to explain priming and acquisition patterns in monolingual children. Given that the model is based primarily on probabilistic input and output, it is not straightforward how it would capture bilingual processing in either L1 or L2. There is some literature discussing the extent to which bilingual speakers are sensitive to probabilistic factors in their L2. Some accounts of L2 processing suggest that L2 speakers are less sensitive to predictions in their second language compared to native speakers (e.g., Grüter et al., 2017; Kaan, 2014). However, emerging research increasingly supports the opposite view, indicating that L2 speakers do engage in predictive processing (e.g., Dussias et al., 2013; Hopp, 2013). Further priming research (discussed in Section 2.2.3) shows that bilingual adults have a sense for structural probabilities and show enhanced priming for less frequent structures, which is in line with monolinguals. However, these initial structural preferences sometimes diverge from those of native speakers, depending on language proficiency, instructional language acquisition (e.g., classroom emphasis on particular structures), structural realizations in the L1, and structural complexity (see, Jackson & Ruf, 2017; Kaan & Chun, 2018). Therefore, we need elaborated

accounts on within language priming in bilinguals that can capture such factors. On these grounds, we believe that the Implicit Learning Account can provide a good explanation for processing within a language in bilingual children and adults if early bilingual language processing is similar to that of monolingual children.

Chapter 3: The Dative Alternation (DA)

In the previous chapter, we examined the emergence of abstract representations in children, drawing on theoretical accounts, the literature on structural priming, and other studies on language acquisition. Given that structural priming is a valuable tool for exploring early representations in both children and adults, we also highlighted key effects—such as abstract priming, lexical boost, surprisal, and cumulative priming—that have been identified in decades of priming research with both monolingual and bilingual populations. These effects are central to the two priming studies reported in the present dissertation. Since our priming studies focus on the dative alternation (DA), we will further elaborate in this chapter on the typology of the DA in English as an example of a structurally and historically similar language to German. Further, we will examine the properties of the German dative alternation, its behavior in adult native speakers, and how and when it is acquired across development, drawing on existing literature.

3.1 Dative alternation in English

In our everyday communication, we can choose how to express the same message by using different wording possibilities offered by the languages we speak. One alternative broadly investigated in the literature is the *dative alternation* (DA), which denotes transfer events. To express a transfer event in everyday interactions, a speaker requires a ditransitive verb (such as *give, bring, send*) and arguments expressing three theta roles (agent, theme and recipient), which results in using either the double object structure (DO) or the prepositional object structure (PO):

(1) a. *The girl sent the basket to the boy*. (PO)
[The girl]$_{AG}$ sent [the basket]$_{TH}$ [to the boy]$_{REC}$

b. *The girl sent the boy the basket*. (DO)
[The girl]$_{AG}$ sent [the boy]$_{REC}$ [the basket]$_{TH}$

The dative alternation was first extensively investigated in English, and from various linguistic perspectives including semantics, pragmatics, information structure, animacy, phonological weight, and heaviness (Bresnan & Nikitina, 2008; Goldberg, 1992; Levin & Rappaport Hovav, 2005; Mukherjee, 2005). All of these approaches have shed light on

restrictions that govern a speaker's choice when formulating a ditransitive message. As a consequence, several accounts of the relationship between the PO and DO variants in the dative alternation have been proposed:

(1) *The monosemy view* proposes that the PO and the DO do not differ in meaning and are considered as two possible syntactic realizations expressing the same concept (Baker, 1988; Butt et al., 1997; Larson, 1988).

(2) *The polysemy view* puts forward that each argument structure is governed by its own underlying semantics; that is, the structure itself encodes a meaning. For the DA, the polysemy view holds that a DO denotes *caused possession* and a PO denotes *caused motion* (Harley, 2002; Krifka, 1999, 2004; Pesetsky, 1995; Pinker, 1989). A more recent subtype of this approach is *the verb sensitive view* based on the assumption that it is not only the construction that entails different meanings, but the verb itself can determine the meaning of the two structural realizations. In other words, verbs should be grouped into classes and, depending on the verb's class, the verb can convey either the same meaning in a PO and DO construction, such as *caused possession*, or different meanings, where the PO can denote *caused possession or motion* and the DO *caused possession* only (Rappaport Hovav & Levin, 2008, p.132).

(3) *The information structure (and other factors) view* claims that differences in information structure are responsible for the choice between the two alternatives. These include phonological weight, heaviness, focus, givenness, definiteness, pronominality, animacy of the constituents, and discourse accessibility (Arnold et al., 2000; Bresnan & Nikitina, 2008; Collins, 1995; Hawkins, 1994; Wasow, 1997)

The semantic approaches (monosemy, polysemy) emerged first, and not much was known about other factors influencing the choice between one or the other variant. However, recent studies have provided important evidence that the DA is rather driven by the information structure approach. Under this approach, DA is best understood as a statistical tendency influenced by lexical biases and gradient probabilistic factors rooted in linguistic experience, where speakers favor one structure over another based on prior exposure and usage frequency (e.g., Bresnan & Hay, 2008; Ford & Bresnan, 2013). This perspective models structural choice as a result of various factors (Bresnan, 2007) and challenges earlier semantic-based accounts. For instance, Bresnan and Nikitina (2008) analyzed large corpora and reported that so-called non-alternating verbs can occur in both DA structures, highlighting the limitations in semantic views (e.g., **Susan whispered/yelled/mumbled… Rachel the news)*. Evidence for

probabilistic production also comes from cross-corpus (Bresnan & Ford, 2010; Rohdenburg & Schlüter, 2009; Schneider, 2007). Moreover, verb bias towards PO or DO have been shown to predict eye movements in reading studies (Tily et al., 2009). Other findings show that verb bias patterns can shift through new experiences and may also depend on animacy, definiteness, pronominality, and constituent length (Bernolet & Hartsuiker, 2010; Coyle & Kaschak, 2008; Peter et al., 2015; Theijssen, 2012). These studies collectively suggest that both the frequency with which verbs appear in particular structures and a range of other linguistic factors within the structure, along with prior language experience, play a significant role in shaping subsequent language production and comprehension.

3.2 Dative alternation in German

With respect to languages across the world, it has been shown that the DA is not a common phenomenon (Harley 2002, Haspelmath 2005; Malchukov et al., 2010; Siewierska 1998). Siewierska (1998:179) for example, studied the occurrence of the DA in 219 languages and found that only 6% of these languages allowed the shift between the structural alternatives. German belongs to these 6% and allows the DA to a certain extent. This finding highlights how exceptional the DA is in a global linguistic environment. Importantly, the DA in German allows for more variation in word order than in English, and shows a much stronger overall bias towards one structure over the other.

3.2.1 DO and PO structures

Ditransitive transfer constructions in German are very similar to their English counterparts on the syntactic level, as shown in (3). While on the surface syntactic level, examples (3a) and (3b) are identical across German and English, the properties of the DA diverge between the two languages in several respects.

(3) a. *Das Mädchen schickte den Korb zu dem Jungen*. (PO)
[Das Mädchen]AG schickte [den Korb]TH [zu dem Jungen]REC
The girl sent the basket to the boy. (PO)
b. *Das Mädchen schickte dem Jungen den Korb.* (DO)
[Das Mädchen]AG schickte [dem Jungen]REC [den Korb]TH
The girl sent the boy the basket. (DO)

First and most importantly, the DO (3b) is the most frequent structural dative construction used in German (Dehé, 2004; Rappaport Hovav & Levin, 2008), while PO and

DO are relatively balanced in English. Although the PO (3a) is possible in German and occurs frequently with specific transfer verbs (such as *schicken* 'send'), the main structural bias is still towards the DO option. Second, the two languages diverge at the morphological level because German requires case marking on arguments. That is, subjects and objects are marked for case and gender, which is realized on the articles.

Third, German also allows two different prepositions to precede the recipient/goal in the PO structure: *an* and *zu*. Interestingly, these prepositions take different cases: *an* takes the accusative case and *zu* takes the dative case. *An* is more commonly used with the dative case and denotes location, meaning touching the surface of an entity *Die Uhr hängt an der Wand* 'The clock hangs on the wall' and therefore is rarely used with animate objects (Moilanen 1979:130). However, when *an* is used with accusative objects, the meaning becomes spatial (Zwarts 2005:3), denoting transfer. *Zu*+dat and *an*+acc are classified as directional prepositions answering the question of *where to*. Note that the two prepositions are not always interchangeable within the PO; the verb itself, as well as the semantic cues, determine whether one or both prepositions are acceptable. Moreover, according to Adler (2011:48), the preposition *zu* denotes a transfer in location, but not a possession *Die Lehrerin schickte die Schüler zum Direktor* 'The teacher sent the pupils to the principal'. Matzel (1976:177-178) also assumes that the two prepositions differ in meaning.

3.2.2 Non-canonical word order

As in many languages that have a powerful case-marking system, the order of the two objects in the argument structure can be switched in German (Neeleman & Weerman 1999); this represents another considerable contrast to English. The structures in (3a) and (3b) demonstrate the default structural option in German, but the arguments of the two sentences can also be expressed in the opposite order. This is known in the literature under the terms *scrambled* or *non-canonical* word order (4).

(4) a. *Das Mädchen schickte zu dem Jungen den Korb*. (PO scrambled)
[Das Mädchen]AG schickte [zu dem Jungen]REC [den Korb]TH
, *The girl sent to the boy the basket.' (PO scrambled)

b. *Das Mädchen schickte den Korb dem Jungen.* (DO scrambled)
[Das Mädchen]AG schickte [den Korb]TH [dem Jungen]REC
, *The girl sent the basket the boy.' (DO scrambled)

Compared to English, German shows much more flexibility with the order of arguments. The scrambled word order is rarely used by German speakers (Eisenbeiß, 1994; Sauerman & Höhle, 2018) and is observed predominantly in the DO structure. A number of studies show that factors like definiteness, animacy, information structure, givenness, nominal vs. pronominal objects, discourse factors, focus, and long before short affect the object switch in DOs (Haider & Rosengren, 1998; Hinterhölzl, 2006; Höhle, 1982; Lenerz, 1977; Müller, 1999; Pappert et al., 2007; Røreng, 2011; Struckmeier, 2014; Uszkoreit, 1987). Scrambled word order is less common for the PO than for the DO in German, though it is not as restricted as in English (Drenhaus & Féry, 2008; Eisenbeiß, 1994; Pechmann et al., 1994). The only analysis on scrambled word order in POs, to our knowledge, was carried out by Wegener (1985). The two variants (canonical vs. scrambled PO) have been examined from a semantic perspective, but their distribution within a fixed linguistic context has not been fully explored. As a result, we have limited insight into the factors that influence shifts in object order, and we lack a clear understanding of how widely such structures are accepted in the population.

3.2.3 Preference for DO over PO

As noted earlier, the PO and DO variants are more or less balanced in English depending on the bias of individual verbs. In German, however, the DO structure is typically strongly preferred (Callies & Szczesniak, 2008; Dehé, 2004; König & Gast, 2007; McFadden, 2004, p.110). A key gap in the research on the German dative alternation is the lack of studies examining the frequency distribution of PO and DO structures based on the verb used—specifically, verb bias effects and structural preferences among German speakers. While research on the DA in English has provided a detailed analysis of factors influencing post-verbal argument selection, most of the existing research for German has focused on double-object constructions (Bühring, 2000; Dehé, 2004; Drenhaus, 2004; Meinunger, 2006; Müller, 1999; Sabel, 2002), examining either structural typologies or the occurrence of non-canonical object orders (non-default argument structures) in relation to factors like information structure (focus), prosody, markedness, and definiteness. In contrast, the prepositional object structure has received very little attention in the literature; it has primarily been studied from a semantic approach, resulting in stronger overall support for *the polysemy view* (Meinunger, 2006; Wagner, 2003; Wunderlich, 2005) and its subtype *the verb sensitive view* (Adler, 2011; Proost, 2014, 2015). A few of these studies looked at animacy effects, information structure,

or language contrasts in certain verbs. However, most of this work is based on author intuitions and is rarely supported by actual data or statistics. Some work on the DA in German has taken the perspective of projectionist theories; however, researchers disagree in most of their views on datives (Hole, 2014; Meinunger, 2006; Wegener, 1985).

Callies and Szczesniak (2008: 172-173) suggested that only verbs that entail physical and not metaphorical movement, such as *werfen* 'throw' but not *diktieren* 'dictate', can take a PO. They further point out that verbs such as *geben* 'give' or *reichen* 'hand' can only be used in the PO structure with particles or prefixes (for instance, *weitergeben* 'pass on', *überreichen* 'hand over') and that the root forms may be used if the speaker wishes to strongly emphasize the recipient (see also Liamkina, 2008). The only study we are aware of that applied a statistical approach to investigate the distribution of POs and DOs is by De Vaere et al., (2018). However, the authors investigated only one dative verb *geben* 'give' in a newspaper corpus (DeReKo) and attempted to determine the factors influencing structural choice, guided by factors that have been found to affect structural choice in English. The authors showed that the verb *geben* 'give' is indeed used in spontaneous production in the PO form although rarely (roughly 4% of DA structures). Some research has also demonstrated that well-established factors such as heaviness of the constituents (Hawkins, 1994) and information structure (Bresnan, 2007) for the dative alternation in English also influence the use of PO for this verb in German (DeVaere, De Cuypere, & Willens, 2018; Willems, De Cuypere & De Vaere, 2019). Importantly, German differs markedly from English in that many fewer verbs can be expressed in the PO construction (Sabel, 2002; Sprouse 1995). This asymmetry in verb compatibility, which results in a strong structural bias toward the DO construction, highlights a key typological distinction between the two languages.

3.3 *The development of the DA in monolingually-raised children*

Research on English-speaking children has provided valuable insights into how they use the dative alternation and the factors influencing structural choice. Dative verbs, which are common in child-directed speech, are frequently used by young children. By age three, children can produce both prepositional object (PO) and double object (DO) constructions (Campbell & Tomasello, 2001; Huttenlocher et al., 2004; Snyder & Stromswold, 1997). They typically acquire DO constructions first, with PO structures following shortly after. Also, many low-frequency dative verbs are more likely to appear in the PO form in children, suggesting that frequency may play a role in determining structural preference. Additionally, other factors such as givenness or the type of referring expression used (full noun phrase vs.

pronoun), can influence structural choices in children (de Marneffe et al., 2012; Stevens, 2010). For example, children may be more likely to produce the PO form when the theme argument is given or when referring expressions are pronominal. These findings highlight the complexity of dative alternation acquisition in children, indicating that multiple linguistic and cognitive factors—such as verb frequency, syntactic structure, and information structure—interact to shape how children use and acquire different syntactic constructions.

In German, there is very little literature on the acquisition patterns of the dative alternation in children and almost no child studies looking at probabilistic factors of the two alternates. In line with most adult research on datives, most child studies also focused on double object constructions and how the two objects are preferably ordered by children depending on various factors such as pronominality, animateness, definiteness, focus, and givenness (Drenhaus, 2004; Drenhaus & Féry, 2008; Höhle et al., 2014; Roeper, 1973; Sauerman & Höhle, 2018). A series of studies conducted by Eisenbeiss (1994, 2003) and Clahsen et al., (2006) report that the dative case is typically acquired last, following the nominative and accusative cases. Importantly, Eisenbeiss also reports that children rarely produce PO structures, with a notable example being *geb auch an Pauline* 'give also to Pauline'. However, children sometimes use prepositional phrases to express the recipient in place of the indirect object (IO) although they have mastered dative marking on IOs. These findings suggest that, while PO structures do appear in child speech, they are relatively infrequent, and their use may be influenced by developmental factors, such as language impairment or the progression of case acquisition.

Woods (2012) is the only study we are aware of that specifically examined the development of the dative alternation in monolingual German-speaking and English-speaking children, as well as bilingual German-English children. She analyzed a relatively small dataset of naturalistic child and child-directed speech from two children—Caroline (von Stuttenheim, 2004) and Leo (Behrens, 2006)—who were recorded between the ages of one and four years. Woods' primary focus was on the development of three common verbs used in dative constructions by children in this age range. Her study aimed to explore how these children acquired the dative alternation and whether there were any differences between the monolingual and bilingual groups in their use of dative structures. Her results indicated that *geben* 'give' was the first verb used by children and appeared between 2;1 and 2;4 in both children. According to her data in German, only Leo started to produce *geben* 'give' in the PO structure, with the first instance around age 2;6 followed by another four PO productions by age 2;9 and one more such token at age 3;6, compared to 86 DO structures. The next verb that

both children started using was *bringen* ‘bring’, which emerged at 2;6 to 2;9 years of age. Interestingly, the first structure used by Leo with *bringen* ‘bring’ was a PO (*du brings die zum Bahnhof* ‘you bring her to the train station’), whereas Caroline used the DO form first. With respect to the last verb *zeigen* ‘show’, Caroline produced it in the DO construction at age 2;7, whereas Leo used the first dative with *zeigen* ‘show’ much later at 3;2 years of age. Crucially, both children did not use this verb in the PO structure. Woods then compared her observations with data from American English-speaking children studied by Snyder & Stromswold (1997) and summarized that both German and English children acquire datives around the same time and there is no obvious difference in timing of acquisition between the two languages (see Table 1).

	American English (Snyder and Stromswold, 1997, p.290)	Caroline	Leo
DOC	2;2,15	2;4,28	2;1,3
PC	2;6,24	2;9,8	2;6,10

Table 1: Age of acquisition for DO and PO structures in English children (taken from Snyder & Stromswold, 1997) and German-speaking children (Caroline and Leo) (Woods, 2012, p. 15).

Further, Woods observed that German-speaking children demonstrate an awareness of the restrictive use of one structural type over the other depending on the verb. For example, no child in her study used the DO-only restricted verb *zeigen* ‘show’ in a PO construction. Most notably, German-speaking children displayed a strong preference for DO structures and produced PO structures only rarely, suggesting an early awareness of the bias in their target language. In addition, German-speaking children acquire a sense of the German case marking system early on, a system that English-speaking children do not need to learn.

In another study by Schönenberger et al. (2011), the authors elicited spontaneous use of PO vs. DO structures through pictures and puppet actions with the verbs *geben* ‘give’ and *schenken* ‘give (a gift)’. They tested successive bilingual German-speaking children with the background languages Turkish (group 1) or Polish and Russian (group 2), and compared their production with monolingual German-speaking children (group 3). In line with Woods (2012), the German-speaking children (N=14) aged between 2;4 and 5;0 rarely produced PO constructions in their elicited speech: only three PO utterances were observed, two of which came from the youngest child (2;4). Of these three instances, the preposition *für* 'for' was used

twice, and *von* 'of' once. Since the authors lacked longitudinal data and were curious whether these children might have produced more PO instances over a longer developmental period, they examined two German corpora from the CHILDES database (MacWhinney, 2000)—Simone (Miller, 1979) and Caroline (the same child studied by Woods, 2012)—to search for instances of ditransitive constructions with the verbs *geben* 'give' and *schenken* 'give as a gift'. They found very few instances (3-4) of indirect object use, most of which were in pronominal form (e.g. *Ich gebe* ***ihm*** *das Buch*, 'I give him the book') and none of these were expressed with the PO structure.

3.4 The development of the DA in bilingually-raised children

While the acquisition of the dative alternation has been studied to some extent in monolingual children, especially concerning the DA and the frequencies with which these occur, literature on the DA in bilingual children remains limited. The acquisition of ditransitive structures may challenge bilingual children due to reduced input in each language and the need to manage two grammatical systems during development. It is important to understand how bilingual children come to acquire and differentiate the structural options in each language, as well as the frequencies with which these occur if both DO and PO structures are possible. In addition, it is important to understand how cross-linguistic influence (CLI) may play a role in shaping early patterns.

In one study, Zarqane (2009) found greater use of POs in English in the production of 15 French-English simultaneous bilingual children (4;8 to 7;8) compared to French and English monolingual children. A similar effect was observed in adult bilinguals, although these speakers had substantially less exposure to French. Zarqane explained this by an influence from French, where only the PO structure is allowed, while English allows both DO and PO. However, Zarqane did not find differences in either comprehension or grammaticality judgments between bilingual and monolingual children.

Woods (2015) investigated the dative alternation in 25 English–German bilingual children (ages 4;9–8;8) compared to 29 English monolinguals, focusing on verbs with varying alternation patterns. Children watched animated video clips designed to elicit dative constructions. Results showed unilateral cross-language influence from English into German – from the more flexible alternation system in English to the more restrictive system in German. There was no influence from German into English. In German, the bilingual children overused the PO form even with verbs that are typically restricted to DO (e.g., *zeigen*, *geben*), using PO about 30% of the time. This pattern was not found in proficient bilingual adults,

suggesting a developmental delay in acquiring verb-specific structural constraints. In English, bilingual and monolingual children performed similarly in production and comprehension (act-out task), though bilingual children made more errors with DO structures involving animate objects or pronouns (e.g., *Give her the frog*). This finding indicated a delayed acquisition of case marking in German. In grammaticality judgment tasks featuring DO/PO violations, bilingual children were less accurate than monolingual peers—neither PO nor DO were fully mastered. However, while bilingual children were more accurate on PO ratings, monolingual children performed better on the DO, suggesting differing sensitivities to grammatical rules depending on structural type. In sum, Woods concluded that while the elicited production task shows evidence for cross-language transfer effects, the act-out task (comprehension) and grammaticality judgment task indicate more of an ongoing acquisition process rather than an end state of the phenomena under investigation caused by CLI. Thus, the overall results suggest that bilingual children have the same syntactic competence as monolingual children, as both groups showed comparable difficulties with semantic constraints for verbs. Differences emerged on the semantic level when verbs are tied to particular structural realizations both in English and German. However, these differences may reflect a slower pace in bilingual language attainment, due to receiving less input compared to monolingual peers.

In another study conducted by Schönenberger et al. (2011), the authors demonstrated similar findings by showing that bilingual German-speaking children with Turkish as their home language produced the indirect object as a prepositional phrase with the verbs *geben* 'give' and *schenken* 'give (a gift)' significantly more often (roughly 38%) than children with Polish or Russian as their home languages (roughly 18%) and monolingual German controls (roughly 1-2%). These findings suggest ongoing acquisition processes, rather than cross-linguistic transfer effects, since the PO structure does not exist in Turkish. In line with Rothweiler, Babur & Krofke (2007), the authors also observed generalizations from the assignment of the accusative case to the dative case (e.g., *ich schenke den Hund*$_{\text{ACC}}$ instead of *dem Hund*$_{\text{DAT}}$) in both bilingual child groups. This pattern was also present in monolingual children, although less frequently and suggests similar morpho-syntactic acquisition processes.

In summary, cross-language influence may occur during language acquisition in bilingual children, but is not always present and often rather reflects a delayed or ongoing acquisition process for the ditransitive construction. These findings require more research in order to determine whether the observed differences between monolinguals and bilinguals are

indeed cross-language influence or rather a specific developmental phenomenon that disappears or improves with better mastery of the language across development.

3.1.5 Motivation for studying the DA in German

While there has been considerable work on various aspects of language acquisition and grammar in both English and German languages, the specific focus on prepositional object structures in German in both adults and children is underexplored. It is not clear to which extent the PO is used and accepted compared to the DO counterpart, and which verbs allow the alternation and which do not. Although some research attempted to define restrictions on alternation regularities as a function of the verb at the semantic interface, corpora and naturalistic production data has demonstrated the opposite (Bresnan & Nikitina, 2008; Eisenbeiss, 1994; 2003; Proost, 2015; De Vaere et. al., 2018). In particular, most approaches used were based on semantic categorizations supporting either the multiple meaning or the verb sensitive view and were mainly based on author intuitions rather than empirical research. For instance, verbs such as *geben* 'give' or *reichen* 'hand' initiated debates with quite controversial conclusions in the literature. The verbs were primarily classified to permit only the double object structure, with some potential for the prepositional object structure under certain conditions, yet they can occasionally be found used in natural speech contrary to these criteria. Hence, according to the available literature which was mainly concerned with the double object construction and the ordering of the two NPs (scrambled word order), the general impression arises that the literature ignores the PO alternate due to its rare occurrence in the language. Interestingly, research on the PO alternate seems to be more present in comparative studies between bilingual and monolingual groups, possibly due to a greater use of this structure in other languages spoken by bilinguals. Another challenge determining factors affecting structural alternation in German compared to English, lies in the language typology. Although both languages allow PO and DO structures, the restrictions on PO usage in German are much more subtle and require more sophisticated and better-controlled experimental methodologies in order to elicit this construction. As previously reported, German works differently at the morphological level and even at the semantic level compared to English. Thus, the most powerful diagnostics of the alternation behavior for English proved to be based on probabilistic approaches which revealed insights into verb biases as well as the statistical tendencies with which both options occur in the language. Therefore, it is important to study the dative alternation in German by taking into account probabilistic information.

Another potential gap in research is the clearly understudied developmental research on the emergence of the PO alternate in German-speaking children. Because the PO is rarely produced in German, and the few studies of the development of the dative alternation in German investigated very small child samples and only a few dative verbs, the question arises: when are children aware that the PO exists and what are the factors influencing the alternation? When do children realize that certain verbs alternate whereas others do not? To which extent is one structure preferred over the other in both child and child-directed speech? Since most data on dative use focuses on DO structures and research on the PO alternative is extremely limited, it would be very useful to study naturalistic child and child-directed speech from a probabilistic perspective.

Chapter 4: Studies on DA in German-speaking children and adults

In preparation for the design of materials for our priming study, which encompasses both children and adult control groups, we initially conducted three empirical studies assessing the dative alternation (DA) of specific verbs in German in contexts familiar to participants. This preliminary investigation was crucial for understanding which ditransitive verbs are accessible to children in the age range from 3 to 8 years of age and whether these allow the dative alternation.

First, we analyzed corpora from five German-speaking children to assess the use of the DA for seven ditransitive verbs that are well known by children from an early age (Study 1). The results yielded various insightful findings; however, given that the corpora consisted of naturalistic speech and the data regarding PO production was quite limited, this analysis was unable to address all pertinent questions. For instance, there were not enough tokens to obtain conclusive results on which verbs allow or do not allow the PO structure and whether the verbs that allow a PO alternate prefer the preposition *an* or *zu* 'to'. Further, most of the ditransitive structure tokens included pronominals or demonstratives rather than full NPs. For these reasons, we decided to use an experimental method in order to elicit more evidence for structures containing full noun phrases, such as NP V NP NP or NP V NP PP structures, by using a sentence completion task (picture description) and an acceptability judgement task (comprehension ratings) for adults. The first study has not yet been published and is presented here in Section 4.1. The latter two studies were published together in a peer-reviewed book chapter which is provided in Section 4.2.

4.1. Study 1: Corpus analysis on child and child-directed speech on the dative alternation (DA) in German

4.1.1. Introduction

In the present study, we investigated the use of the dative alternation in both child speech and child-directed speech using longitudinal data from five German-speaking children aged 1;6 to 7;5, taken from the CHILDES database (MacWhinney, 2000). To explore this, we selected seven well-known verbs commonly used by children in this age range: *bringen* 'bring', *geben* 'give', schicken 'send', and *reichen* 'hand', *zeigen* 'show', and *werfen* 'throw' and *verkaufen* 'sell'. Some of these verbs are well-documented in the literature on the acquisition of the dative alternation in German (Eisenbeiss et al., 2006; Schönenberger et al., 2011; Woods, 2015), while others have not been extensively studied in relation to this

phenomenon. In particular, the verbs *reichen* 'hand', *werfen* 'throw', *verkaufen* 'sell' and *schicken* 'send' have received little attention in the child literature. Another gap in research is information on the use of the two prepositions *an* and *zu* 'to' for the PO in German-speaking children and adults. While some literature encountered other types of prepositions (*für* 'for', *von* 'from', etc.), we were only interested in the production of PO structures with the two prepositions denoting transfer. Further, research on the use of ditransitive structures, particularly those that incorporate full noun phrases (NPs) as objects, remains scarce.
The following research questions were addressed:

1) At what age do children acquire and use the verbs of interest: *geben, bringen, schicken*, *reichen, zeigen*, *werfen* and *verkaufen* and what is the frequency distribution among them across age?
2) When do double object (DO) and prepositional object (PO) structures appear in children's and child-directed speech?
3) How frequent are DO structures compared to PO structures, and to what extent does this depend on the structural biases of verbs?

4.1.2 Method

Caroline, Leo, Pauline, Sebastian, and Cosima (MacWhinney 2000; Leo: Behrens 2006; Cosima, Pauline, Sebastian: Lieven and Stoll 2013; Caroline: Von Stutterheim 2014) were regularly recorded as part of longitudinal studies on language development. While all five children were part of these recordings, the specific time frames of their data collection varied slightly, as outlined in Table 2, which shows the periods when child or child-directed speech were recorded for each child and the number of recordings. Cosima, Pauline, and Sebastian were recorded until age 7;5 roughly, while Caroline's and Leo's recordings stopped at age 4;3 and 4;11 respectively. A detailed description of the corpora, the recording intervals, analyzed files of child and child-directed speech, age ranges, and more information about the parents' education as well as other interlocutors during recordings, are presented in Appendix A. All data had previously been transcribed by native speakers in CHAT format following the standards of the CHILDES initiative (MacWhinney, 2000).

Children	*Recording Periods*	*Total N of recordings*
Caroline	0;10 – 4;3	240
Leo	1;11 – 4;11	501
Pauline	0;00 – 7;11	129

Sebastian	0;00 – 7;5	134
Cosima	0;00 – 7;2	130

Table 2: Recording periods and the total amount of recordings on child and child-directed speech for each of the five monolingual German children.

The computer program CLAN was used to generate a list of all the instances in which children or caregivers produced the verbs *geben* 'give', *schicken* 'send', *bringen* 'bring', *werfen* 'throw', *reichen* 'hand', *zeigen* 'show' *and verkaufen* 'sell' in any sentence type (imperative, interrogative or declarative) and in any tense possible in German (*Präsens* 'simple present', *Präteritum* 'simple past', *Perfect* 'present perfect', *Plusquamperfec*t 'past perfect', *Futur I und II* 'future', *Konjunktiv* 'subjunctive'). These utterances were retrieved from the corpus in the age range 1;6–7;5 by using the command[4] *kwal* which selected the specified words in a separate file from the corpus. This file contained all conjugated verb forms across all tenses and sentence types possible in German.

4.1.3 Coding

The extracted utterances were split into three types – intransitive, transitive and ditransitive utterances. Every ditransitive utterance was segmented into a ditransitive verb followed by an indirect and direct object, which could occur in either order. Each object could be a pronoun, a demonstrative, a full noun phrase, or a proper name. Every ditransitive utterance was coded as either a prepositional object (PO) structure or a double object (DO) structure. Ditransitive structures were coded as 'PO' when the verb was followed by a direct object NP specifying the theme and then by an indirect prepositional object specifying the recipient (NP_PP; e.g., *die Puppe zu*$_{\text{DAT}}$ *der Mama* 'the doll to the mother'; *die Puppe* an$_{\text{ACC}}$ *die Mama* 'the doll to the mother'). Sentences with the reversed object order were considered as the scrambled version of the PO (NP_PP; e.g., *zu*$_{\text{DAT}}$ *der Mama die Puppe* 'to the mother the doll'. The scrambled structure of a PO does not allow a pronoun as the direct object to follow the indirect object NP or an indirect pronoun (**Der Mann bringt zu dem Jungen/zu ihm es* '*The man brings to the boy/to him it').

Ditransitive structures were coded as 'DO' when the verb was followed by an indirect object NP specifying the recipient and then by a second direct object NP specifying the theme

[4] Full command for token extraction was '*kwal +s@ditransverbs.cut +w1 -w1 @'* where *kwal* searches for user-specified words, *+s@ditransverbs.cut* specifies the file in which all forms of the word forms are included (see Appendix B) and *+w1 -w1* tell CLAN to include the first line before and after the keyword.

without any prepositions (NP_NP; e.g., *der Mama die Puppe* 'the mother the doll'), and were coded as scrambled when the objects had the reversed order but did not contain a preposition (NP_NP; e.g., *die Puppe der Mama* 'the doll the mother'). However, the children hardly ever produced two full NPs after ditransitive verbs. Instead, the children usually used one full NP or proper name and either a pronoun or a demonstrative, or no full NPs and only pronouns and demonstratives (e.g., *un(d) ich geb(e) dir auch (ei)ne Spritze* 'and I will also give you an injection', Sebastian, age 5;6–5;11; *ich zeig dir das* 'I'll show you that', Pauline, age 6;0–6;5). These instances were also coded as DO but were coded accordingly as pronominal or demonstrative objects. Note that the scrambled version of the DO allows the objects to be realized as pronouns and demonstratives. When the verb is followed by a direct object that is a weak pronoun like *es* 'it', the scrambled structure is the most frequently used word order (e.g., *Nicklas, ich zeig(e) (e)s dir* 'Nicklas, I'll show it you', Leo, age 2;0–2;5). But if the verb is followed by a demonstrative like *das* 'this', the scrambled version is still possible but is the less frequent variant (e.g., *dib [: gib] das mir* 'give this me', Sebastian, age 4;0–4;5). In the analysis, we also encountered all tenses (simple present, present perfect, past perfect, simple past, future and subjunctive) and all types of sentences (interrogative, declarative and imperative). All ditransitive verbs were also coded for the person (1,2,3) and number (singular, plural) of the subject. Because ditransitive verbs in German also use prefixes that slightly change the meaning and are separate words in English (e.g., *hinbringen* 'to bring to there (contextually known location)', *mitbringen* 'bring with you', *übergeben* 'hand over', *überreichen* 'hand over', *wegschicken* 'send away', etc.) we included them as tokens, but took them out for the final analysis.

4.1.4 Results

Altogether, we found 733 tokens for child speech and 2047 tokens for child-directed speech for the verbs of interest in the age range of 1;6–7;5. We then removed all verbs with prefixes, as well as all tokens that were not identifiable for structure type. Thus, our final sample comprised 544 tokens for child speech and 1981 tokens for child-directed speech. Because we intended to test children in the priming study as young as three years of age, we conducted the following analyses separately for the full age range (up to 7;5) and for a smaller early age range (up to 2;11). Data from children were included from age 2;0, the point at which children typically begin producing consistent two- and multi-word utterances (Brown, 1973; Tomasello, 2003). To capture relevant input influencing early production, adult child-directed speech was included from six months earlier (age 1;6). This approach ensures that

the adult input available to children before the onset of syntactic production is considered in the analysis, as early input has been shown to play a crucial role in shaping syntactic development (e.g., Huttenlocher et al., 2002; Pine et al., 2013). Including this earlier period also allows us to capture relevant tokens in child-directed speech that children might hear but not yet adopt during earlier stages, providing a more complete picture of the linguistic environment influencing development.

The first research question focused on the age at which the target verbs (*geben*, *bringen*, *schicken*, *reichen*, *zeigen*, *werfen*, and *verkaufen*) appear in both child and child-directed speech, as well as the frequency with which they are produced. Overall, all of the target verbs were used by both children and adults, indicating that children are familiar with them. Table 3 displays the total number of uses (the frequency distribution) of these verbs in both child and child-directed speech for two age ranges: up to 7;5 years (overall frequencies across all ages) and up to 2;11 years (frequencies for early acquisition period). Across all ages, the most frequent verb for both children and caregivers was *zeigen* 'show', followed by *geben* 'give' and *bringen* 'bring'. The other four verbs occurred relatively rarely; the most frequently used verb was *werfen* 'throw', followed by *schicken* 'send', then *reichen* 'hand', and the least used verb was *verkaufen* 'sell'.

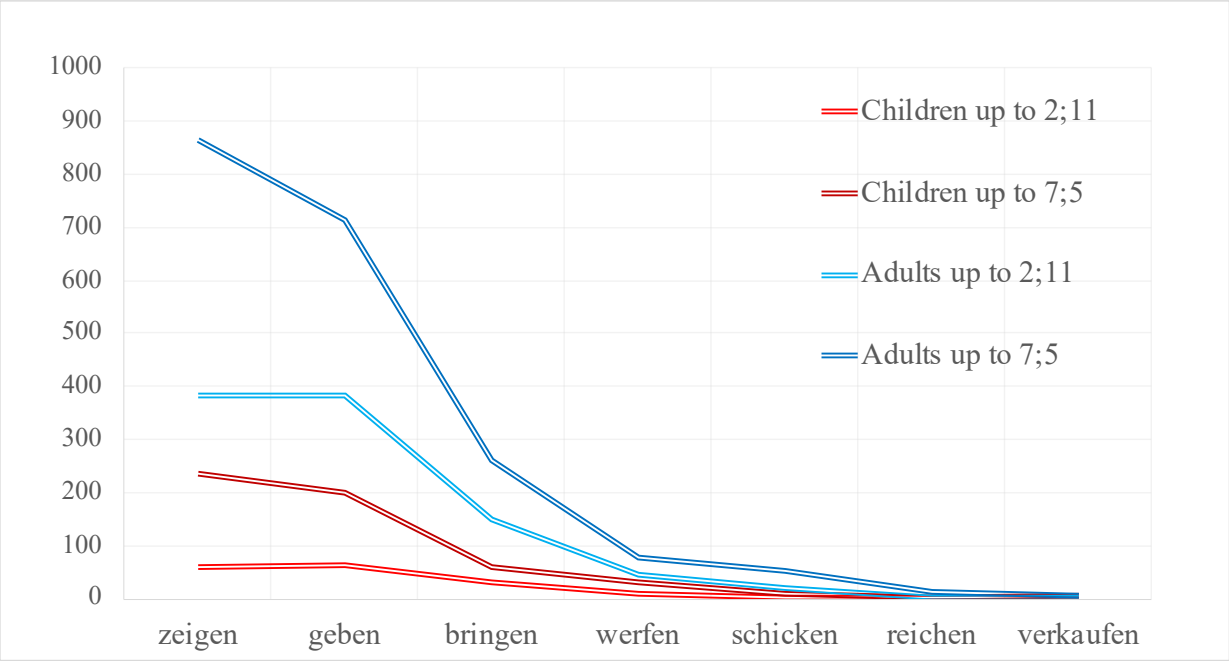


Table 3: Frequency distribution of the seven verbs in child and child-directed speech up to 2;11 and 7;5 years of age.

However, at the individual level, the results revealed some variation in the use of the most frequent verbs (*zeigen* 'show', *geben* 'give', and *bringen* 'bring') among the children, as shown in Table 4. For instance, Caroline produced *zeigen* 'show' and *geben* 'give' substantially more often than the other children in the age range 2;0–2;11. Interestingly, these patterns shifted after age 3;0, with other children producing those two verbs more frequently. Importantly, the least frequent verbs (*reichen* 'hand' and *verkaufen* 'sell') were only produced by Leo a few times, whereas the other children did not use these verbs at all. Although *schicken* 'send' was also extremely rare in child speech, it was still produced at least once by Caroline, Leo, and Pauline. Recording periods were much longer in Caroline and Leo compared to the other three children during the early stages, which may explain why they exhibited more instances of rarely used verbs. Additionally, Caroline's production shows little change between the earlier and later time windows, likely because her recordings ended earlier, around age 4;3. Importantly, the adults' data aligned with the overall frequencies of the individual verbs produced by the children, especially during the earlier period, consistent with findings from child language acquisition research. Interestingly, we observed the verbs *reichen* 'hand' and *verkaufen* 'sell' in Sebastian's child-directed speech in the earlier time window, suggesting that although these verbs were only produced by Leo, they were also heard by Sebastian. In the later period, we observed slightly more tokens of very rarely used verb, including *schicken* 'send', appearing not only in Leo's child-directed speech, but also in that of Cosima, Sebastian, and Pauline.

a)

CHILDREN

2;0 - 2;11	***Caroline***	***Leo***	***Cosima***	***Sebastian***	***Pauline***
zeigen	29	10	10	5	7
geben	27	21	3	3	10
bringen	7	13	1	5	3
werfen	0	4	2	2	1
schicken	1	1	0	0	1
reichen	0	2	0	0	0
verkaufen	0	2	0	0	0
Sum	64	53	16	15	22
2;0 - 7;5					
zeigen	30	52	69	44	40
geben	29	30	24	65	53
bringen	7	21	2	22	6
werfen	0	6	7	15	4
schicken	1	4	0	1	1

reichen	0	2	0	0	0
verkaufen	0	6	0	0	0
Sum	67	121	102	147	104

b)

ADULTS

1;6 - 2;11	***Caroline***	***Leo***	***Cosima***	***Sebastian***	***Pauline***
zeigen	147	102	37	63	35
geben	118	136	39	40	49
bringen	36	57	11	30	14
werfen	6	12	9	13	4
schicken	13	2	0	2	2
reichen	0	2	0	1	0
verkaufen	0	0	0	1	0
Sum	320	311	96	150	104
1;6 – 7;5					
zeigen	147	204	145	254	113
geben	118	196	96	159	143
bringen	36	84	28	73	38
werfen	7	14	17	29	10
schicken	13	13	3	14	9
reichen	0	9	1	2	0
verkaufen	0	0	2	3	1
Sum	321	520	292	534	314

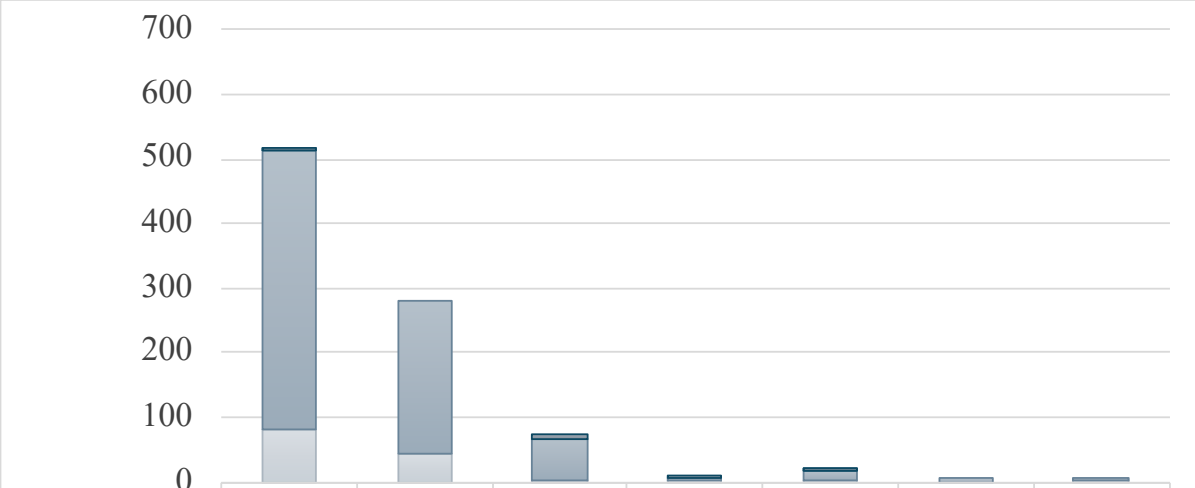
Table 4. Frequency distribution of the seven verbs, shown individually for each child between ages 2;0–2;11 and 2;0–7;5 (a), and for each adult (in child-directed speech) between ages 1;6–2;11 and 1;6–7;5 (b).

In sum, these results indicate that children are likely familiar with all seven verbs as young as 2;0–2;11 years. Given that probabilistic factors in verb distribution play an important role in everyday interactions, only the three most frequently used verbs (*zeigen* 'show', *geben* 'give', and *bringen* 'bring') appear consistently in both child and child-directed speech. In contrast, the verbs *werfen* 'throw', *schicken* 'send', *reichen* 'hand', and *verkaufen* 'sell' are extremely limited in child speech, but the caregiver data indicate that children are nonetheless exposed to these verbs.

The second and third research questions focused on the age at which children begin using ditransitive DO and PO structures, the frequency with which these structures occur in speech, and the extent to which these distributions are influenced by specific verbs. Consistent with findings in previous literature (Woods, 2012), children began producing DO

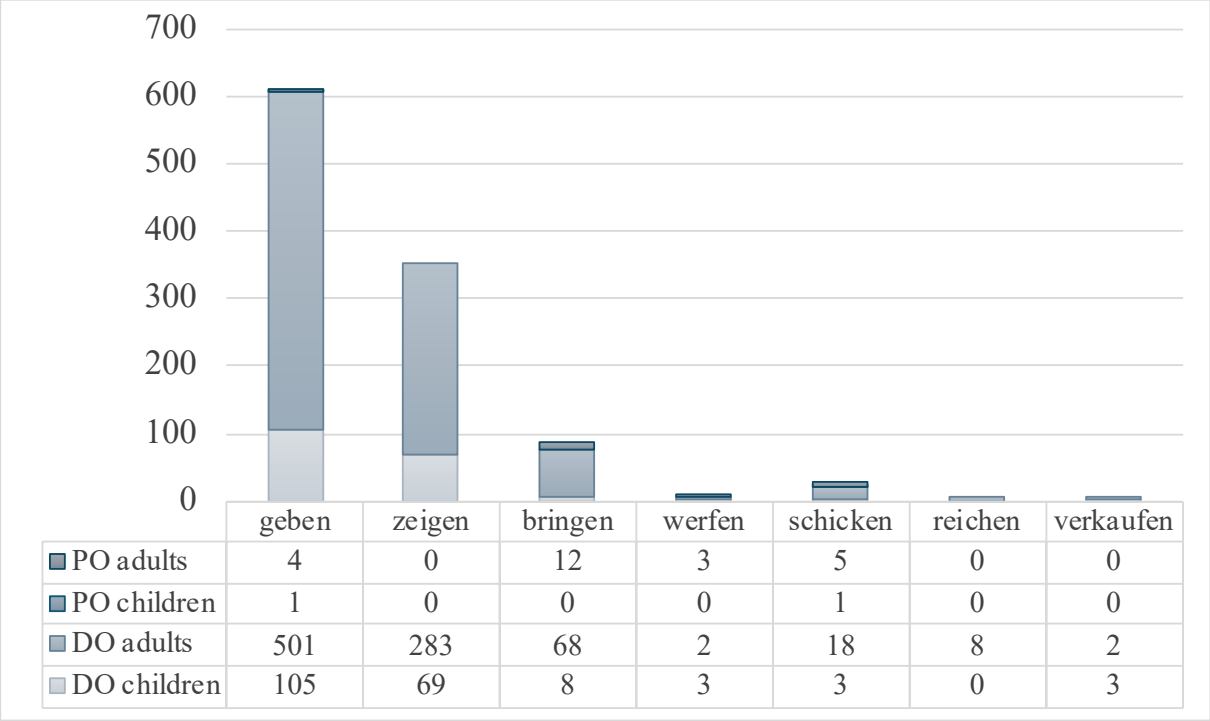
structures relatively early, around ages 2;0–2;11, primarily with the verbs *geben* 'give' (N=20) and *zeigen* 'show' (N=7). For the other verbs, only one token was found for each of *bringen* 'bring', *werfen* 'throw', and *verkaufen* 'sell', while no tokens were recorded for *reichen* 'hand' or *schicken* 'send'. Between ages 3;0–3;11 and 4;0–4;11, the distribution of these verbs remained largely unchanged, though there was a slight increase in token frequency for *geben* 'give' (N=37 at age 3, N=24 at age 4) and *zeigen* 'show' (N=24 at age 3, N=19 at age 4). During the same age ranges, *schicken* 'send' appeared twice in DO constructions (N=2), while the other verbs saw little change, with token frequencies remaining at 0 to 2 tokens. A similar pattern was observed in child-directed speech, albeit with a higher frequency of tokens, particularly between ages 1;6–2;0, which aligns with findings from corpus studies on English monolingual children. Table 5 shows the token frequencies for DO and PO structures in both child and child-directed speech up to age 4;11, based on data added together from all five children. We also present data from the full dataset up to age 7;5; however, recordings for two children (Caroline and Leo) ended earlier, around age 4;3 to 4;11.

a)



	geben	zeigen	bringen	werfen	schicken	reichen	verkaufen
PO adults	3	0	7	3	4	0	0
PO children	1	0	0	0	1	0	0
DO adults	433	236	62	2	15	7	2
DO children	81	43	4	3	2	0	3

b)



	geben	zeigen	bringen	werfen	schicken	reichen	verkaufen
PO adults	4	0	12	3	5	0	0
PO children	1	0	0	0	1	0	0
DO adults	501	283	68	2	18	8	2
DO children	105	69	8	3	3	0	3

Table 5: The number of uses for DO and PO structures in child and child-directed speech up to 4;11 (a) and up to age 7;5 (b).

These results suggest that children as young as three years of age possess an abstract representation for the DO structure, although they prefer to use these constructions with verbs most frequently represented in their mental lexicon. Note that *reichen* 'hand' was very rarely used in either child or child-directed speech; it occurred only twice in Leo's utterances in a transitive form and 12 times in child-directed speech, 8 of which were uttered in a DO form. These instances were the only ones found over the whole age range under investigation. We thus assume that although children might be acquainted with *reichen* 'hand', we lack sufficient evidence according to our data. Importantly, most DO structures up to age 7;5 contained either a full noun phrase (NP) or proper name combined with a pronoun/demonstrative, or did not include an NP/proper name at all, that is, containing only pronouns and demonstratives (children: 90,1%, adults: 84,7%). Out of the 191 DOs produced by the children, only 18 contained full NPs for both the indirect and direct objects (exclusively with *geben* 'give' and *zeigen* 'show'), and included one more instance of non-canonical word order. Among the 882 DOs produced by adults, 130 contained full NPs for both the indirect and direct objects (with the same verbs as in the child data, plus *bringen* 'bring'), and five more were used in non-canonical word order.

With respect to the development of the PO structure for the verbs of interest, we found an essential distinction in the use of the PO compared to the DO: overall the PO structure was uttered by children only once for the verb *geben* 'give' combined with the preposition *zu* (*aber ich muss zu dir auch Geld geben* 'but I also must give to you money'; Leo at age 3;6-3;11) and once for the verb *schicken* 'send' combined with the preposition *an* (*ich schicke den an Schnabelwalen* 'I'll send him/that one to beaked whales'; Leo at age 2;6 – 2;11). Both POs contained either a pronoun or a demonstrative as an indirect object and a full NP as a direct object. No other verb was ever used in a PO structure according to our criteria[5]. In adults, the use of POs also occurred relatively rarely. In the age range 1;6–7;5 (whole data set), *bringen* 'bring' was the most frequently used verb in a PO (N=12) and was always used with the preposition *zu* (or *für* 'for', not included in analysis). *Schicken* 'send' was used only five times with both prepositions *an* (3x) and *zu* (2x). Interestingly, *geben* 'give' was also used four times with the preposition *an* only, followed by *werfen* 'throw' with the preposition *zu* (N=3). *Zeigen* 'show', *reichen* 'hand' and *verkaufen* 'sell' did not occur in a PO structure among either children or interlocutors. In the age range 2;0–4;11 (see Table 5) this pattern remained: *bringen* 'bring' (N=7) was followed by *schicken* 'send' (N=4), *geben* 'give' (N=3) and *werfen* 'throw' (N=3) with no PO productions for the rest of the verbs. Overall, the two time windows between age 1;6-4;11 and 1;6-7;5 did not show any substantial differences, particularly with respect to PO use, with only a few additional instances in the later time window with the same verbs.

To answer the last question of whether some verbs were particularly biased toward one structural alternative over the other, no clear pattern has emerged yet. The data suggests that the verb *bringen* 'bring' may be used most often in a PO form compared to the rest of the verbs that were used in a PO. However, due to limited amount of spontaneous usage, this question remains open.

4.1.5 Discussion

In the current corpus analysis, we investigated the development of seven commonly used ditransitive verbs in child and child-directed speech. This study aimed to determine suitable verbs for the child priming experiment, and to and obtain preliminary knowledge about which ditransitive verbs are frequently used by children and whether and when they are realized as POs and DOs. German is similar to English in that it allows the alternation

[5] We also observed one more token of the PO structure (*ich b(r)ing noch (ei)n Messer für dich* 'I'll bring a knife for you'; Pauline at age 2;0-2;5) but with the preposition *für* 'for' which we did not include in the analysis (see coding).

between the DO and PO structures. However, since the literature is very scarce on the PO realization in German and since the PO structure is assumed to appear rather rarely in the language, it is important to understand whether children are familiar with this construction either in their input or their production, and whether they also have a robust representation of the DO structure when lexical NPs are arguments of the verb rather than pronouns or demonstratives.

Our findings align partially with existing English-speaking child literature on language acquisition. Specifically, we observed that the DO structure is indeed produced by age three and that children acquire the DO form first (Campbell & Tomasello, 2001; Huttenlocher et al., 2004; Snyder & Stromswold, 1997). Our data also shows the emergence of the DO in children around age 2;0–2;11; the most frequently used verbs are *geben* 'give' and *zeigen* 'show' (in line with Woods, 2012), with only a few tokens for the other verbs between age 2;0–4;11. Crucially, the distinction in acquisition is that while English-speaking children quickly pick up on PO constructions almost at a similar period of development as for DOs, German-speaking children seem to encounter only very few instances of the PO structure in their input and seem to produce such structures minimally (in line with Clahsen etal., 2006; Schönenberger et al., 2011; Woods, 2012).[6] In our data, we only found two such instances produced by Leo (once with *geben* 'give' and once with *schicken* 'send').

Further, neither the children nor the interlocutors ever produced the PO construction with the verb *zeigen* 'show', which is in line with the rest of the literature suggesting that this verb is restricted to DO only (e.g., Callies & Szczesniak, 2008; Dehé, 2004; Drenhaus, 2004; Meinunger, 2006; Woods, 2012).

An obvious difficulty with spontaneous speech data is that PO realizations with the target verbs may have occurred, but these instances might not have been captured during the recorded observation periods. Thus, our findings on the basis of spontaneous speech data may not fully capture the variability and richness of language use, requiring an experimental approach that would allow us to elicit or judge such structures. Overall, the results did answer our main question, demonstrating that the PO structure is a rare phenomenon in German and the frequency with which this alternate is used is similar in child and child-directed speech. However, because the PO was produced so rarely, we are not able to conclude which prepositions are preferred if an alternation arises, and also cannot conclude to which extent verbs are biased towards a particular alternate.

[6] Small differences between our findings and those of Woods (2012) and Schönenberger et al. (2011) for the same children are likely due to differences in search criteria and exclusion criteria.

With respect to the DO, the results show clearly that these are used commonly in child and child-directed speech. However, because almost 90% of the DO structures were realized with a pronoun or demonstrative as the theme and/or recipient, it is less clear how familiar children are with the structure when the indirect and direct objects are full lexical NPs (although we did find instances of both the object slots realized with full NPs for two verbs as young as 2;0-2;11). Nevertheless, we can claim that children possess a representation for an *agent-verb-recipient-theme* structure which they can fill with smaller units. Consistent with existing literature regarding the use of scrambled word order within DO structures in German-speaking children (Drenhaus, 2004; Roeper, 1973; Sauermann & Höhle, 2018), our findings show that German-speaking children and adults possess a robust representation of the default word order *dat+acc* and produce the scrambled word order relatively rarely. Further, we found evidence that children use all seven ditransitive verbs (although *reichen* 'hand' was never used in a ditransitive construction), and that children acquire probabilistic information about frequencies of verbs and the structures they occur in early in development (in line with Höhle et al., 2004, 2006). Our findings also add to a large body of child language acquisition literature suggesting that all patterns observed in the linguistic behavior of children reflect structures of typical language use by caregivers. This alignment demonstrates a remarkable sensitivity to distributional information in young learner's linguistic environment.

4.2. Publication 1

Kholodova, A., & Allen, S.E.M. (2023). The dative alternation in German: Structural preferences and verb bias effects. In E. Zehentner, M. Röthlisberger, & T. Colleman (Eds.), *Ditransitives in Germanic languages: Synchronic and diachronic aspects* (pp. 264–298). John Benjamins. https://doi.org/10.1075/sigl.7

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In our first published study, we extended our research on the DA to adults based on the outcomes from the research on the DA in child and caregiver spontaneous speech presented in Section 4.1. Although the study in Section 4.1 provided valuable insights into the use frequencies of seven ditransitive verbs and their acquisition patterns across different age groups in both child production and caregiver speech, it remained unclear which verbs allow or do not allow the PO alternate due to the limited number of PO instances overall. For

example, neither the child data nor the adult data revealed whether the verbs *zeigen* 'show', *reichen* 'hand', or *verkaufen* 'sell' can be used in the PO construction. The literature claims that a PO is impossible with *zeigen* 'show' and our corpus data supports this given that we saw no POs in 235 child instances and 863 adult instances of ***zeigen***. However, it would still be relevant to experimentally test whether a PO with *zeigen* is impossible or just vanishingly rare. Substantial literature also claims that a PO is impossible with *geben* 'give', but our corpus analysis revealed a few instances of PO in both child and caregiver data. This shows the importance of examining actual production in a range of types of data. It is possible that caregivers use the PO form of such verbs to emphasize the recipient for better comprehension by the child (Liamkina, 2008), or that they employ this structure in more specific contexts or pragmatic situations. With respect to *reichen* 'hand' and *verkaufen* 'sell', any interpretation is impossible since only a few tokens appeared in the data. More targeted measures are necessary to confirm observations from the corpora analysis and find answers to the remaining questions.

For these reasons, we designed a sentence completion task and a grammaticality judgement task for German-speaking monolingually-raised adults. In the sentence completion task, we studied how participants would describe a ditransitive action (picture) for each verb by having free choice of producing either a DO or PO structure. We were also interested in investigating which prepositions are predominantly used by native speakers in PO constructions, given that German allows two prepositions, *an* and *zu*, compared to just one preposition, *to*, in English. The choice of preposition also depends on the verb (see subsection 3.2.1). In the grammaticality judgment task, we examined the verbs of interest by presenting participants with either a PO or DO structure, while manipulating the occurrence of both prepositions (*zu* and *an*) to assess the degree of acceptability for each preposition with respect to the verb. Since some verbs allow both prepositions, we were particularly interested in identifying the preferred one. Note that all items in the sentence completion and acceptability judgment task required (sentence completion) or included (grammaticality judgment) full NPs rather than pronouns or demonstratives for all arguments, so that we could obtain information relevant for our priming study, where we intended to have items with full NPs for all arguments.

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The dative alternation in German

Structural preferences and verb bias effects

Alina Kholodova and Shanley Allen

Many ditransitive events can be expressed in German using either the indirect object construction (IOC) or the prepositional object construction (POC). While most previous research on ditransitives in German has focused on the IOC, very little attention has been paid to the much rarer POC or to individual verb biases for the IOC vs. the POC. We investigated structural preferences of native speakers of German using elicited production and acceptability judgment studies. The results show that the POC is not as restricted as previously thought, and that different modalities (i.e., production vs. comprehension) reveal different aspects of verb biases, which can be easily missed when relying on one type of data.

Keywords: verb bias, German, ditransitive structure, structural preference, dative alternation, probabilistic language production, syntactic representation

1. Introduction

Languages often offer more than one structural option for expressing a particular message. One common example of this is found with ditransitive verbs, usually used for expressing transfer events, which appear in many languages throughout the world (Malchukov, Haspelmath, and Comrie 2010). As discussed in the introduction of this volume, ditransitive verbs such as *give*, *bring* and *send* typically appear with three arguments – an agent, a theme, and a recipient. However, these verbs can be expressed using two different constructions, differentiated by the realization of the recipient (the theme is always a direct object). In one construction, the recipient is realized as a prepositional phrase; we refer to this as the prepositional object construction (POC), illustrated in Examples (1a) and (2a). In the other construction, the recipient is realized as a second object which can be either a direct object as in English (1b) or an indirect object as in German (2b).

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We refer to these as the double object construction (DOC) for English and the indirect object construction (IOC) for German.

(1) English ditransitives
  a. Prepositional object construction (POC)
  [The boy]$_{AG}$ gave [the present]$_{TH}$ [to the girl]$_{REC}$.
  b. Double object construction (DOC)
  [The boy]$_{AG}$ gave [the girl]$_{REC}$ [the present]$_{TH}$.

(2) German ditransitives
  a. Prepositional object construction (POC)
  [Die Frau]$_{AG}$ schickte [den Brief]$_{TH}$ [an den Beamten]$_{REC}$.
  the.NOM woman sent the.ACC letter to the.ACC official
  'The woman sent the letter to the official.'
  b. Indirect object construction (IOC)
  [Die Frau]$_{AG}$ schickte [dem Beamten]$_{REC}$ [den Brief]$_{TH}$.
  the.NOM woman sent the.DAT official the.ACC letter
  'The woman sent the official the letter.'

German has obligatory case marking on articles and pronouns, which helps to differentiate the role of each noun phrase. It also allows two different prepositions in the POC: some verbs take *an* (with accusative case), some take *zu* (with dative case), and some allow both. *Schicken* 'send' in (2) is a verb of the latter type, and thus could also occur with *zu*. Finally, the order of the theme and recipient can also be reversed for both the IOC and the POC in German – a phenomenon which has been the subject of much debate in the field (e.g., Büring 2001a, 2001b; Drenhaus 2004; Meinunger 2006; Pappert et al. 2007). Since this reverse word order is not common with ditransitives where both theme and recipient are expressed by full NPs (Müller 1999; Büring 2001b; Gast 2007) – the focus of the present chapter – we do not consider these structures further here (but see Rauth, this volume, for a discussion of the degree of word order variability in present-day German as well as older stages of the language; as well as Gerwin and Röthlisberger, this volume, for a discussion of alternative orders in present day English).

In most languages, individual verbs are permitted to appear in one of the two structures only (POC or DOC/IOC). However, in a relatively small number of languages including English and German, as well as most other Germanic languages – as detailed in several contributions to this volume, alternation between the two structures is possible for individual verbs. This variation of structure for a given verb is termed the *ditransitive alternation* or *dative alternation*.

The dative alternation has been most extensively studied in English, in which both the DOC and POC variants are frequently used with a wide range of alternating verbs (e.g., Mukherjee 2005; Goldberg 2006; Bresnan and Nikitina 2008;

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Rappaport Hovav and Levin 2008; also Dubois, or Röthlisberger, this volume). Much attention in the literature on English has thus been paid to investigating verb biases and speaker preferences for the POC vs. the DOC, as well as the conditions under which each construction is preferred. In German, however, the IOC is overwhelmingly preferred for almost all verbs that alternate (Dehé 2004; Rappaport Hovav and Levin 2008), and thus the focus of research has rather been on the two possible word order variants within the IOC (i.e., recipient-theme vs. theme-recipient, also see Rauth, this volume). In contrast, very little attention has been paid to the factors triggering a preference for the POC vs. the IOC. The few existing studies on the relation between the POC and the IOC tend to be descriptive rather than quantitative, focusing on the semantics of each structure and on the theoretical implications of these semantic analyses, but providing little quantitative information about which verbs allow which structures to which extent. Further, there is considerable controversy over whether prototypically ditransitive verbs such as *geben* 'give' and *reichen* 'hand' allow the POC at all (Sabel 2002; Dehé 2004; Drenhaus 2004; Callies and Szczesniak 2008; Rappaport Hovav and Levin 2008; Adler 2011; Proost 2015; De Vaere, De Cuypere, and Willems 2018; cf. also Ussery and Petersen, this volume, on the acceptability of prepositional patterns in Faroese).

In the present chapter, we seek to fill this gap in the literature by providing new empirical data on the use of the POC vs. the IOC in German. We report on two studies designed to quantitatively investigate the structural preferences of German native speakers: a written sentence completion task in which participants describe a ditransitive scene, and an acceptability judgment task in which participants rate the acceptability of ditransitive structures. These studies focus on six of the most commonly used ditransitive verbs in German: *bringen* 'bring', *geben* 'give', *reichen* 'hand', *schicken* 'send', *verkaufen* 'sell', and *zeigen* 'show'. In the remainder of this section, we outline previous research on the dative alternation in general and also in German, as well as details of the present study.

1.1 The dative alternation

Considerable research has focused on documenting and understanding structural preferences in the use of the dative alternation, especially in English. Early theoretical accounts were mainly interested in the semantics of this alternation, with two contrasting views: The *monosemy* view, which postulates that both alternants express the same concept without any meaning difference (e.g. Larson 1988; Butt, Dalrymple, and Frank 1997), and the *polysemy* view, which assumes that different syntactic realizations express different meanings with the DOC denoting 'caused possession' and the POC denoting 'caused motion' (Pinker 1989; Goldberg 1992;

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Pesetsky 1995; Krifka 1999, 2004; Harley 2002). Related to the latter is the *verb sensitive* view which assumes that the POC can have either a 'caused motion' or a 'caused possession' meaning, dependent on the verb it is used with (Rappaport Hovav and Levin 2008). Increasingly, attention has also turned to the role of information structure and other related factors in explaining the structural preferences, rather than simply verb-related underlying semantic differences (e.g. Wasow 1997; Polinsky 1998; Biber et al. 1999; Givón 1984; Arnold et al. 2000; Van Valin 2007), and to dialectal differences (Hughes and Trudgill 1996).

Other factors that have been shown to influence the structural alternation include phonological weight, heaviness, focus, givenness, definiteness, pronominality, animacy, and discourse accessibility (Erteschik-Shir 1979; Hawkins 1994; Collins 1995; Arnold et al. 2000; Wasow 2002; Bresnan and Nikitina 2008). Under this view the dative alternation is not a categorical phenomenon, but instead a gradient probabilistic phenomenon (e.g., Bresnan and Hay 2008; also Dubois, as well as Röthlisberger, this volume). The specific lexical bias – that is, speakers' preferences for using a particular verb in one or the other structure – can be statistically modelled by including various predictors (Bresnan 2007). All of these factors have been shown to affect a speaker's syntactic choice across different types of data including corpus studies, grammaticality judgment tasks, and sentence completion tasks as well as comparative studies across varieties of English (Collins 1995; Bresnan et al. 2007; Bresnan and Nikitina 2008; Bresnan and Ford 2010).

Interestingly, certain structures appear in some types of data but not others. For example, Bresnan and Nikitina (2008) found that manner-of-speaking verbs (e.g., *whisper*, *yell*, *mumble*) occurred only in the POC in the one-million-word Switchboard corpus of English telephone conversations. However, they were able to find those same verbs in the DOC in a search of some 47 billion words on the Internet, in phrases like *she muttered him a hurried apology* and *you just mumble him an answer*. Evidence for probabilistic production also comes from cross-corpus studies between varieties of English (American, Australian, British) which have shown that speakers of these varieties do not differ in the grammatical rules they use, but in the statistical occurrence of the structures in spoken and written language (Schneider 2007; Rohdenburg and Schlüter 2009; Bresnan and Ford 2010; Röthlisberger this volume).

Ditransitive structures have also been investigated extensively in German. However, given that the IOC is typically strongly preferred in German (McFadden 2004; Dehé 2004; Callies and Szczesniak 2008), research on structural preferences has focused mainly on the use of the two variants of the IOC: the canonical recipient-theme structure vs. the non-canonical theme-recipient structure. Numerous studies have sought to enumerate the typologies of these two variants, and to explore the patterns of use of each with respect to factors including information

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structure (focus), prosody, markedness, animacy, nominality, definiteness, and c-command rules (Müller 1999; Keller 2000; Büring 2001a, 2001b; Sabel 2002; Kempen and Harbush 2003a, 2003b, 2004, 2005; Dehé 2004; Drenhaus 2004; Meinunger 2006; Gast 2007; Pappert et al. 2007; De Vaere, De Cuypere, and Willems 2018).

In contrast to the abundant research on the IOC, the alternation between the IOC and the POC in German has received very little attention in the literature. Most of the existing research has been theoretical rather than empirical, focusing on the semantic equivalence between the IOC and the POC. This work generally concludes that the two structures differ in meaning, supporting either the *polysemy* view (Meinunger 2006; Wunderlich 2006) or its subtype, the *verb sensitive* view (Adler 2011; Proost 2014, 2015). A few of these studies have also touched on the effects of animacy, definiteness, information structure, whether a pronoun or noun phrase is used to express the referents, or typological differences between languages regarding certain verbs, but again from a theoretical perspective based on introspective data rather than on quantitative analysis of empirical data. There is just one recent study that has quantitatively investigated the occurrence of the IOC vs. the POC (De Vaere, De Cuypere, and Willems 2018). This study analyzes occurrences of the verb *geben* 'give' in a large newspaper corpus (DeReKo), using Bresnan et al.'s (2007) probabilistic approach to determine the effect on structural choice of several factors that have been found to play a role in English (e.g., definiteness, pronominality, animacy, concreteness, voice, number). The rest of the literature on ditransitives in German tends to ignore the POC or to even explicitly deny its existence for many verbs. There is general consensus that the POC is in principle possible, although relatively rare, with several verbs including *bringen* 'bring', *schicken* 'send', and *verkaufen* 'sell', and that it is not possible for many other verbs including *zeigen* 'show'. However, there is considerable controversy over whether it can be used with verbs such as *geben* 'give' or *reichen* 'hand' (Sabel 2002; Dehé 2004; Drenhaus 2004; Callies and Szczesniak 2008; Liamkina 2008; Rappaport Hovav and Levin 2008; Adler 2011; Proost 2015; De Vaere, De Cuypere, and Willems 2018). Some authors claim that the POC is not grammatical at all for these verbs. Others suggest that *geben* 'give' and *reichen* 'hand' can be used in the POC in some limited contexts, such as in order to emphasize the recipient, in certain sub-senses of the verbs in question (e.g., in a 'donate' or 'distribute' sense for *geben*), in certain dialects, or when particles are added to the verb resulting in a different meaning (e.g., *über+geben* 'hand over', *weiter+reichen* 'pass on'). Such particle verbs are well-attested in present-day German and are widely used with the POC.

Some research has also focused on the question of which prepositions are used in the POC. As noted earlier, German allows two prepositions for denoting

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transfer events: *an* and *zu*. The consensus in the literature is that *zu* is typically used with *bringen* 'bring' while *an* is typically used with *verkaufen* 'sell', and that both prepositions are commonly used with *schicken* 'send'. The literature is less clear for *geben* 'give' and *reichen* 'hand' for which, as we observed earlier, there is substantial controversy over whether these verbs occur in the POC at all. Some studies claim that the verb itself as well as various semantic factors determine whether one or both prepositions are acceptable for most ditransitive verbs (Matzel 1976; Adler 2011). However, semanticists typically have differing views on which semantic factors, if any, are relevant (e.g., Erben 1972; Wegener 1985; Meinunger 2006). In general, the literature on POCs is fairly small and introspection-based, and is often not supported by actual data.

1.2 The present study

In sum, although an abundance of information is available about the intricacies of the use of the IOC in German, far less is known about the use of the POC, or about the relationship between the IOC and the POC. As one step towards filling this gap in the literature, we conducted two empirical studies to determine the preferences of German native speakers for the IOC vs. the POC in several common verbs. In contrast with most existing studies, which are corpus- or introspection-based, we opted for two different methods that elicit data directly from participants. The first is a sentence completion task, investigating participants' own production of the IOC vs. the POC in a controlled context (Study 1). The second is an acceptability judgment task, investigating the extent to which participants find different ditransitive constructions acceptable, regardless of whether they spontaneously produce those structures (Study 2). As noted earlier, both studies focus on six of the most commonly used ditransitive verbs in German: *bringen* 'bring', *geben* 'give', *reichen* 'hand', *schicken* 'send', *verkaufen* 'sell', and *zeigen* 'show'. Using these two methods allows us to gather evidence for rarer structures, as well as to collect data in a relatively fixed linguistic context, thus controlling for effects from certain linguistic factors known to affect syntactic choice. We expect that these data will provide new insights into both the use of alternative variants and verb biases in general.

We focus on two main questions across the studies. First, we investigate to what extent speakers prefer the POC vs. the IOC for each of the six verbs. Although the literature is clear that the IOC is the preferred construction in German for those ditransitive verbs that alternate between the IOC and the POC, it is not clear whether this bias is equally strong for every verb, and whether the preferences are consistent across different modalities (e.g., production vs. acceptability judgment). Differences in preferences across modality have been shown, for

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example, in Bresnan and Nikitina (2008) for oral vs. written production of ditransitives in English, or in Keller (2000) and Kempen and Harbush (2005) for corpus analysis vs. grammaticality judgments of IOC variants in German. Further, there is disagreement in the literature about whether two of our verbs – *geben* 'give' and *reichen* 'hand' – allow the POC at all.

Second, we investigate which prepositions (*an* or *zu*) are used in the POC for each of the six verbs, and which of the two is preferred in contexts where both of them would be permitted. As was mentioned above, while the literature agrees that *bringen* 'bring' and *verkaufen* 'sell' use only one of the variants, it is less clear which preposition is preferred for *schicken* 'send' and whether the POC is possible for *geben* 'give' and *reichen* 'hand', and, if so, with which preposition.

The remainder of this chapter is structured as follows: Section (2) reports on the first experiment, viz. a sentence completion task, starting with a description of the methods employed (2.1) before presenting the results (2.2) and discussing them (2.3). Section (3) gives the same information on the acceptability judgment task, featuring an outline of the methods in (3.1), the results in (3.2) and a discussion of the findings in (3.3). Section (4) provides a more general comment on the main questions addressed by means of the experiments, and Section (5) concludes the chapter.

2. Study 1: Sentence completion task

In Study 1, we used a written picture description task to investigate what structural choices participants make when describing pictures of ditransitive events. In order to reduce the influence of animacy on structural choice, we controlled the context of the pictures such that each contained an animate agent, an animate recipient, and an inanimate theme. On the basis of the literature on ditransitive verbs in German, the expectation was (i) that participants would most often use the IOC but (ii) that participants would also occasionally use the POC for all verbs except *zeigen* 'show', which is uniformly reported in the literature to never allow the POC. For the five other verbs, we were particularly interested in exploring the strength of the verb's bias for the POC vs. the IOC. We also investigated preferences for which preposition (*an* or *zu*) was used with each verb in the POC.

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2.1 Method

2.1.1 *Participants*

A total of 996 students and employees (721 male, mean age 24.02 years, SD 5.85) from the Technische Universität Kaiserslautern participated in the sentence completion task. All participants confirmed orally that they were native speakers of German. However, answers to a written question about language background on the response sheet revealed that 316 participants were simultaneous or early successive bilinguals or non-native speakers of German, or did not provide information about their language background. Since these participants did not meet the inclusion criteria, their data were removed from the study. Thus, the final sample included 680 participants (491 male, mean age 24.07 years, SD 5.59).

2.1.2 *Design and materials*

We designed 23 pictures representing an action with an animate agent, an inanimate theme and an animate recipient. The verbs *bringen* 'bring', *geben* 'give', *reichen* 'hand', *verkaufen* 'sell', and *zeigen* 'show' were each represented by four different pictures, while *schicken* 'send' was represented by three different pictures (due to depiction difficulties). For each of the pictures for a given verb, different referents were used for each thematic role (see Appendix). Many referents were repeated across the items because they were easy to recognize (girl, boy, grandmother, etc.). Ease of recognition was important for our design, in which each participant responded to one item, because we wanted to avoid guesses or misinterpretations of the thematic roles depicted.

Half of the pictures for a given scene showed the event occurring from right to left (see Figure 1) and half from left to right. Instructions were written above the picture: *Was passiert im Bild? Ergänzen Sie den Satz mit dem Verb darunter* 'What is happening in the picture? Complete the sentence with the verb provided below'. The target verb (here, *reichen* 'hand') was presented directly underneath the picture in the infinitive form. Below that, the picture description began with the agent (here, *Der Junge* 'the boy'), followed by two lines where the participant could complete the description. Four demographic questions were given at the bottom of the page asking about the participant's age, gender, native language, and age of starting to learn a first foreign language.

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Was passiert im Bild?
Ergänzen Sie den Satz mit dem Verb darunter:

Reichen

Der Junge _____

_____.

Fragebogen

1. Geschlecht: m □ w □
2. Alter: _____
3. Meine Muttersprache ist: Deutsch □ andere Sprache: _____
4. Meine zweite Sprache habe ich im Alter von:
   - □ 0-6 Jahren gelernt
   - □ 7-10 Jahren gelernt
   - □ 11-18 Jahren gelernt

Vielen Dank für Ihre Teilnahme!

Figure 1. Sentence completion sheet with additional background questions about gender, age, native language and the onset of second language learning

2.1.3 *Procedure*

Participants were approached at the entrance to the university cafeteria, asked if they were a native speaker of German and, if so, whether they were willing to participate in a short study. They were also briefly informed about the task as follows: *Sie werden ein Bild sehen, das Sie mit einem Satz beschreiben sollen. Dieses Verfahren wird etwa eine Minute Zeit in Anspruch nehmen. Ihre Beschreibung würde uns als Vergleich zu Kinderbeschreibungen dienen*. 'You'll be given a picture which you should describe using one sentence. This procedure will take you approximately one minute. Your description will serve as a comparison to child

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descriptions'. Each person who agreed was given one response sheet and was instructed to complete the sentence by using the agent and the verb provided, and by using the first description that came to their mind. These instructions were standardized for all experimenters. However, because these were spontaneous conversations in the cafeteria, participants occasionally asked further questions such as *What is this study for?* or *Can I use as many words as I want in the sentence?* All questions were answered with whatever of the following information was pertinent: responses should comprise only one sentence, responses should ideally name all the objects in the picture, and responses could contain as many words as desired. There were no restrictions on the type of words to use. We avoided detailed written instructions because participants might be distracted while reading in the cafeteria, which could lead to misinterpretations of the task.

Two main reasons led us to have each participant describe only one picture. First, we wanted to control for possible priming effects – i.e., the influence of a structure used previously on further production (see Bock 1986). Second, we wanted to avoid possible item confounds by having participants see the same referent in two or more pictures, given that several referents were used more than once across the pictures.

2.1.4 *Coding*

All completions were classified as either an IOC, a POC, or 'other'. Completions were classified as an IOC or a POC only if both the recipient and the theme were realized by lexical NPs. These lexical NPs could include adjectives or attributes with or without articles (e.g., *die nette Oma* 'the nice grandmother', *eine Oma* 'a grandmother', *Oma* 'Grandmother').

Some participants used a different verb than the verb provided for their picture. If the verb was one of the other verbs considered in our study, we included the response in the analysis for that verb rather than discarding the response (0.9% of total data). This was done because the pictures can in principle be described with any of the six verbs, and participants may have just overlooked the verb provided below the picture.

Most completions used a simple main clause. However, we also included completions using more complex syntactic structures (1.7% of total data). These more complex structures took two forms: main clauses including an auxiliary or modal in the expression of the verb (e.g., *Das Mädchen möchte ihrer Oma Blumen schicken* 'The girl wants to send her grandmother flowers'), and infinitive+*zu* constructions where the *zu* preceding the verb is an infinitival marker and not a preposition (e.g., *Das Mädchen denkt daran, ihrer Oma Blumen zu schicken* 'The girl is thinking about sending her grandmother flowers'.

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A completion was coded as an IOC when the agent and verb were followed by a recipient in dative case and a theme in accusative case, with no preposition preceding the recipient (e.g., *Das Mädchen schickt der Oma die Blumen* 'The girl sends the grandmother the flowers'). Non-canonical completions with the theme preceding the recipient were coded as 'other' (1.7% of total data).

A completion was coded as a POC when the agent and verb were followed by a theme in accusative case and a recipient preceded either by the preposition *zu* (with recipient in dative case) or *an* (with recipient in accusative case) (e.g., *Das Mädchen schickt die Blumen an die Oma / zu der Oma* 'The girl sends the flowers to the grandmother'). Each POC was also coded for which preposition was used preceding the recipient: *an* or *zu*. Non-canonical completions with the recipient preceding the theme were coded as 'other' (0.9% of total data).

A completion was coded as 'other' if it did not conform to the requirements for either an IOC or a POC as just described. This 'other' category mainly consisted of the following five structures: (1) completions in which either the recipient or theme was a pronoun or a demonstrative, (2) completions in which the recipient and theme were in the non-canonical order, (3) completions in which a verb was used with a particle such as *zuschicken* 'send over', (4) completions that used verbs other than our six target verbs, and (5) completions that used structures other than ditransitives. The first three were not included as IOCs or POCs because the use of the relevant forms is known to affect syntactic preferences. Although we could have included such completions as an additional category for analysis, there were too few of them to yield meaningful results.

2.2 Results

In the results, we focus on two research questions relating to the sentence completion data. First, we assess the frequency of use for the IOC vs. the POC for each verb, to determine if each verb allows both structures and, if so, what the preference is for each structure. Second, we analyze the use of *an* vs. *zu* for the POC for each verb.

2.2.1 *Use of IOC and POC*

The 680 picture descriptions comprised 404 (59.4%) canonical IOC completions, 103 (15.2%) canonical POC completions, and 173 (25.4%) 'other' completions. We first determined the frequency of completions instantiating the IOC and the POC for each verb (see Table 1).

We then used Bayesian parameter estimation to determine what our data tell us about the degree to which each of the two kinds of completion is preferred over the other. If the use of IOC over POC were hypothetically random, with a

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Table 1. Frequency and percentage of completions in the IOC or POC for each verb

Verb	IOC	%	POC	%	Total N
bringen 'bring'	71	87.7%	10	12.3%	81
geben 'give'	104	97.2%	3	2.8%	107
reichen 'hand'	77	100.0%	0	0.0%	77
schicken 'send'	25	30.9%	56	69.1%	81
verkaufen 'sell'	53	60.9%	34	39.1%	87
zeigen 'show'	74	100%	0	0.0%	74
TOTAL	**404**	**79.7%**	**103**	**20.3%**	**507**

probability p of using IOC and (1-p) of using POC, then the probability of N_I completions using IOC relative to N_P completions using POC would be given by elementary probability theory as

$$P(N_I, N_P|p) = \frac{(N_I + N_P)!}{N_I!N_P!} p^{N_I}(1-p)^{N_P}$$

where *N!* denotes the factorial function

$$N! = N \times (N-1) \times \ldots \times 2 \times 1$$

Bayes's theorem then allows us to infer the relative likelihood, given our data, of one hypothetical value of p over another. Normalizing such that the integrated likelihood over all p from 0 to 1 is one, the formula for the likelihood of p given the data N_I and N_P is

$$L(p|N_I, N_P) = \frac{P(N_I, N_P|p)}{\int_0^1 dp'\, P(N_I, N_P|p')}$$

In this case the normalization integral in the denominator evaluates to another ratio of factorials, and so the final result for the likelihood of p given the data is very similar to the probability of the data given p:

$$L(p|N_I, N_P) = \frac{(N_I + N_P + 1)!}{N_I!N_P!} p^{N_I}(1-p)^{N_P}$$

This likelihood density is plotted for each of our six verbs (see Figure 2). We see that our sample sizes are sufficient to give fairly narrow peaks for all six likelihoods, while the most likely values of p vary considerably among the six verbs, from around 0.3 to above 0.95.

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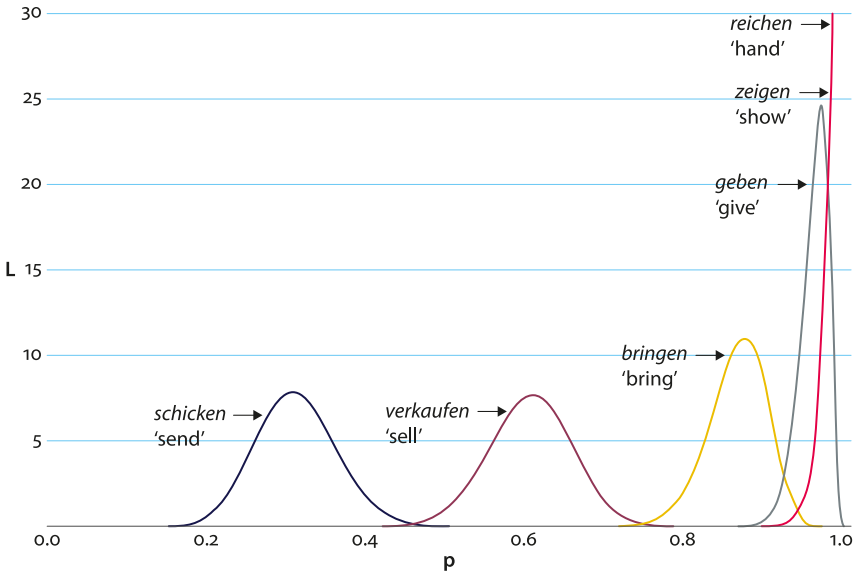

Figure 2. Likelihood density *L* of IOC preference probabilities *p*, for each verb

The horizontal axis *p* in the figure denotes the fraction of IOC completions (as opposed to POC completions) in the entire population of German native speakers. Our finite experimental sample only allows us to estimate *p*; the likelihood function *L*(*p*) indicates how confident and precise an estimate is justified by our data, according to the principles of Bayesian inference. For the verbs *zeigen* 'show', *reichen* 'hand', and *geben* 'give', the preponderance of IOC over POC completions in our sample is so great that a high *p* can be inferred with high confidence: the likelihood of *p* being less than 0.9 in these three cases is extremely low, given our data. However, our data do not rule out that these verbs could occasionally occur in the POC. For the other three verbs, the preponderance of IOC over POC completions in our data is weaker. For *verkaufen* 'sell', for example, the data indicate that *p* is probably in the range 0.5–0.7, but the data do not support a more precise estimate of *p*. The likelihood density curve for *verkaufen* is therefore a lower and broader peak. The most likely *p* for *verkaufen*, given our data, is 60.9%, but the true *p* in the entire population is not too unlikely to be as low as 0.5 or as high as 0.7, if our sample happened to be an unusual one. In sum, on the basis of this Bayesian analysis, we can conclude that *schicken* 'send' is moderately POC-biased, *verkaufen* 'sell' is weakly IOC-biased, *bringen* 'bring' is strongly IOC-biased, and the other three verbs are very strongly IOC-biased.

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2.2.2 *Use of prepositions in the POC*

In the second analysis, we investigated which preposition (*an* or *zu*) was preferred in the POC. Again, we first calculated the frequencies of completions using each preposition for each verb (see Table 2).

Table 2. Frequency and percentage of POC completions with *an* vs. *zu* for each verb

Verb	*an*	%	*zu*	%	Total N
bringen 'bring'	0	0.0%	10	100.0%	10
geben 'give'	2	66.7%	1	33.3%	3
reichen 'hand'	0		0		0
schicken 'send'	48	85.7%	8	14.3%	56
verkaufen 'sell'	34	100.0%	0	0.0%	34
zeigen 'show'	0		0		0
TOTAL	**84**	**81.6%**	**19**	**18.4%**	**103**

We then used Bayesian parameter estimation to determine what our data tell us about the degree to which each of the two kinds of completion is preferred over the other, with a probability p of choosing *an* and (1-p) of choosing *zu*. Following the calculations noted earlier, the likelihood density is plotted for each of the six verbs (see Figure 3).

The sample sizes for three of the verbs are sufficient to give fairly narrow peaks for the likelihoods, with the most likely values of p ranging from 0 (*bringen* 'bring') to 1 (*verkaufen* 'sell'). *Bringen* 'bring' clearly prefers *zu* while both *schicken* 'send' and *verkaufen* 'sell' clearly prefer *an*. Although *bringen* 'bring' and *verkaufen* 'sell' were only used with one of the two prepositions in our data, our sample size is not large enough to rule out that the other preposition is possible with these verbs. For *geben* 'give', the small sample size (3 cases) is not sufficient to support any strong conclusion about p, and so the Bayesian procedure produces a very broad $L(p)$. Since *reichen* 'hand' and *zeigen* 'show' do not appear in the POC at all, the data says nothing at all about p of *an* versus *zu* completion for these verbs. The $L(p)$ curve is flat, indicating that all possible p are still equally plausible given our data.

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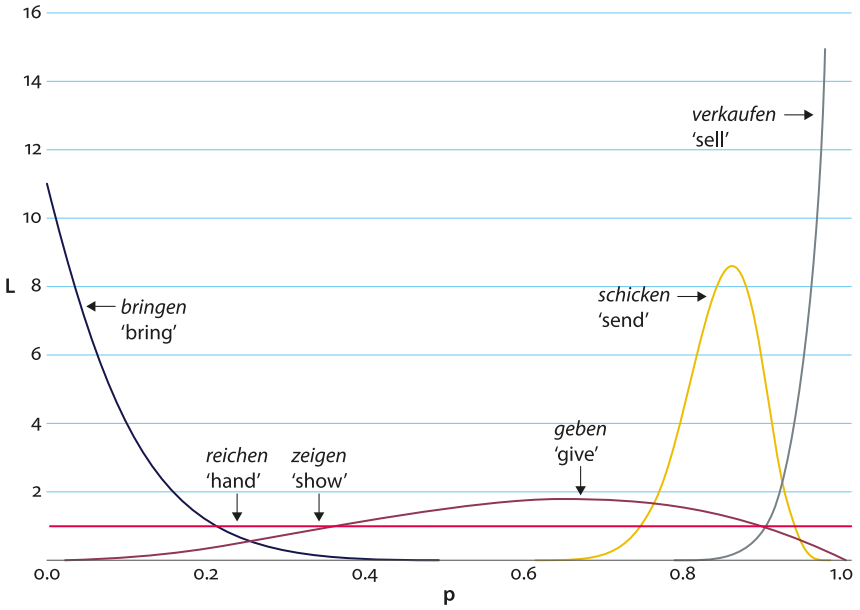

Figure 3. Likelihood density *L* of *an* preference probabilities *p*, for each verb

2.3 Discussion

In Study 1, we used a sentence completion task to investigate the structural preferences of German native speakers for either the POC or the IOC with six commonly used ditransitive verbs. Our first research question was whether participants preferred to use the IOC for all verbs. Two of the verbs – *zeigen* 'show' and *reichen* 'hand' – were only used with the IOC and found to be highly IOC-biased in the Bayesian analysis. This finding is in line with the literature (Dehé 2004: 87; Drenhaus 2004: 86; Meinunger 2006; Callies and Szczesniak 2008: 174; Woods 2012: 13). Three other verbs – *bringen* 'bring', *geben* 'give', and *verkaufen* 'sell' – were used with both structures but showed an IOC bias. Interestingly, the distribution of likelihood of use with IOC is significantly different across these five IOC-biased verbs with *verkaufen* 'sell' showing the weakest bias and *reichen* 'hand' and *zeigen* 'show' showing the strongest biases. In contrast to the other verbs, *schicken* 'send' showed a moderate bias for appearing in the POC. This contradicts Wunderlich's (2006: 35) observation that animate recipients trigger the IOC and inanimate recipients trigger the POC in German, since the recipients in our study were always animate. According to Wunderlich's semantic analysis, the indirect object in the IOC is associated more with a recipient, and in the POC more with a goal. However, our data clearly show that even animate recipients can prefer the POC, possibly depending on the verb. Had our study included inan-

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imate recipients, we might well have observed even stronger preferences for the POC with the verbs under investigation here. Overall, our findings illustrate that German contains at least one POC-biased verb and that, at least for certain verbs, the POC occurs to a greater extent than previously thought. The verbs displaying a relatively large proportion of POC uses merit further careful study in order to understand what linguistic factors trigger the use of POC.

A second main goal was to investigate whether *geben* 'give' and *reichen* 'hand', previously categorized in the literature as non-alternating IOC or only alternating under certain conditions, would occur in the alternative structural variant (POC) in actual production. The literature on the dative alternation with *geben* 'give' and *reichen* 'hand' is divided on this. Several authors claim that German does not allow the dative alternation with core dative verbs such as *geben* 'give' (e.g., Sabel 2002: 231; Callies and Szczesniak 2008: 173; Rappaport Hovav and Levin 2008: 162). Others claim that the POC with *geben* 'give' is possible under the following four conditions: (1) when the speaker wishes to strongly emphasize the recipient, which is suggested to hold for *reichen* 'hand' as well (Liamkina 2008: 156), (2) when it is used in the sense of 'donate' – *Der Professor gab seine Bücher an die Bibliothek* 'The professor donated his books to the library' (Dehé 2004: 87; Adler 2011: 70), (3) when the semantics of the denoted activity imply distribution, payment, giving (in the sense of sending) an article to the newspaper, etc. (Adler 2011: 70), and (4) when used in certain dialects of German – *John gibt das Glas zur Mama* 'John gives the glass to Mommy' (Drenhaus 2004: 86). For *reichen* 'hand', Callies and Szczesniak (2008: 173) suggest that the POC is possible only with particle variants of the verb, such as *weiterreichen* 'pass on' or *überreichen* 'hand over' (e.g., *Er reichte seinem Nachbarn ein Wörterbuch* 'He handed his neighbor a dictionary' (IOC) / *Er reichte sein Wörterbuch an seinen Nachbarn weiter* 'He passed a dictionary on to his neighbour' (POC)). In our study we found that the participants occasionally used the verb *geben* 'give' in the POC, even though it was primarily used in the IOC. This is in line with Proost (2015: 2) and De Vaere, De Cuypere, and Willems (2018: 15) who also found a small number of uses of *geben* 'give' with *an* in the POC in the DeReKo corpus of written German (less than 5% of total ditransitive uses of *geben*). These results, taken together, show that *geben* is indeed used with the POC, though not frequently. Our study did not include information about sentence context or dialect use of participants, so it cannot shed light on what motivates the use of this structure. The verb *reichen* 'hand' was not used in the POC in our study, but our Bayesian analysis leaves open the possibility that it very sporadically does occur in production and just did not arise in the productions of our participants.

Our final research question asked which preposition is used in the POC for each verb. Here our results again support findings from previous literature in that

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bringen 'bring' is typically produced with *zu*, *verkaufen* 'sell' with *an*, and *schicken* 'send' with both prepositions. A new finding is that although *schicken* 'send' was used with both prepositions, we found a strong preference for *an* compared to *zu*. This may be related to the design of our materials which all used animate agents, animate recipients, and inanimate themes. We also found that *geben* 'give' was produced in the POC with both possible prepositions – twice with *an* (*Der Junge gibt ein Geschenk an das Mädl* 'The boy gives the present to the girl', *Der Polizist gibt eine Nettigkeit an die alte Dame* 'The police officer gives something nice to the old lady') and once with *zu* (*Das Mädchen gibt hoffentlich den Ball zu dem Jungen* 'The girl will hopefully give the ball to the boy'). The latter case is interesting given that some research states that the preposition *zu* is not possible with *geben* 'give' (Malchukov, Haspelmath, and Comrie 2010: 49; De Vaere, De Cuypere, and Willems 2018). Despite their small number, these POC completions for *geben* 'give' with different prepositions indicate that much still needs to be learned about the circumstances that make speakers choose a POC with other prepositions than the ones commonly considered acceptable.

In sum, the written production task used in this study provides further information about the alternation behaviour of six commonly used ditransitive verbs in the context of two animate arguments (agent and recipient) and one inanimate argument (theme). However, since relatively few POCs were produced, we could only draw limited conclusions about the possibilities for POC use. Further, we were not able to control for definiteness and pronominal use, as the spontaneous productions from the participants included both definite and indefinite articles for both themes and recipients, as well as pronouns. In order to address these limitations, and also to allow for a more detailed examination of the patterns for *geben* 'give' and *reichen* 'hand' given their limited coverage in the literature, we designed an acceptability judgment task to elicit acceptability ratings for instances containing each of the six verbs occurring in the two structures (POC and IOC).

3. Study 2: Acceptability judgment task

To gain a complementary view of the structural preferences for the dative alternation in comprehension, we elicited acceptability judgments for the POC and the IOC for the same six verbs of interest. Our first goal was to determine the acceptability of the IOC and the POC for each verb, including whether *geben* 'give' and *reichen* 'hand' are restricted to the IOC or also allow the POC. We hypothesized that the POC would receive lower ratings than the IOC, but would nonetheless be rated as acceptable for all the verbs except *zeigen* 'show'. Our second goal was to determine the acceptability of *an* vs. *zu* in the POC for each verb. All of the items

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were controlled for effects of animacy, definiteness, sentence length and concreteness of referents. The differences between Study 1 and Study 2 in design (single measure vs. repeated measures) and item characteristics (inanimate theme vs. animate theme) mean that the studies are not directly comparable. Nonetheless, it is informative to assess both production and comprehension of the dative alternation. As we will show, changing the animacy of the theme in the second study reveals verb-specific patterns that would otherwise have gone unnoticed.

3.1 Method

3.1.1 *Participants*

A total of 42 students and academic employees of the Technische Universität Kaiserslautern participated in the study (mean age 23.7 years, SD 4.6). All participants were native speakers of German, and none had begun learning a second language before the age of 7. Participants were not compensated for their participation.

3.1.2 *Design and materials*

The six verbs from the previous study were also investigated in this study: *bringen* 'bring', *geben* 'give', *reichen* 'hand', *schicken* 'send', *verkaufen* 'sell', and *zeigen* 'show'. We created 18 experimental sentences – three for each verb – which were controlled for animacy, definiteness and constituent complexity (see Appendix). All three arguments in each sentence were animate, in contrast with Study 1 where the theme was always inanimate.[1] The theme was always realized as a definite lexical NP comprising small animals (e.g., bird, turtle) or small humans (baby, child), However, the agent and recipient were realized with proper names in half of the sentences (e.g., *Sarah zeigte Klaus den Welpen* 'Sarah showed Klaus the puppy'), and as definite lexical NPs in the other half (e.g., *Der Junge reichte dem Mädchen den Fisch* 'The boy handed the girl the fish'). This was balanced across verbs as follows. For three of the verbs (*bringen* 'bring', *reichen* 'hand', *zeigen* 'show'), two sentences used proper names for the agent and recipient, while a third sentence used definite lexical NPs. For the other three verbs (*geben* 'give', *schicken* 'send', *verkaufen* 'sell'), one sentence used proper names for the agent

1. The literature shows a preference for animate NPs to precede inanimate NPs in ditransitives across many languages including German (Kempen and Harbusch 2004; Branigan, Pickering, and Tanaka 2007). This is the typical order for IOCs in German. Thus, to avoid the possibility that an inanimate theme would bias participants towards the IOC over the POC, we only used animate arguments in the acceptability judgment task.

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and recipient, while the other two sentences used definite lexical NPs.[2] None of the arguments in this study were repeated across items.

Each sentence appeared in three conditions: IOC (e.g., *Der Bauer verkaufte der Dame die Ente* 'The farmer sold the lady the duck'), POC with *an (Der Bauer verkaufte die Ente an die Dame* 'The farmer sold the duck to the lady'*)*, and POC with *zu (Der Bauer verkaufte die Ente zu der Dame* 'The farmer sold the duck to the lady'). The experimental sentences were distributed across three lists according to a Latin square design, such that each participant saw all 18 experimental sentences but never saw the same sentence in more than one condition. On the basis of the literature and the results of Study 1, we expected that participants would judge 14 of the sentences as grammatical (all six with the IOC as well as eight with the POC), and the remaining four as ungrammatical (viz. POCs with atypical prepositions for the given verb).

The study also included 36 filler sentences comprising both intransitive and transitive sentences with adjuncts. To attain a balance of 50% of the sentences likely to be acceptable and 50% not, we designed 13 grammatical and 23 ungrammatical filler sentences. The ungrammatical sentences included various morphosyntactic errors such as incorrect verbal agreement, prepositions, case agreement, word order, and the like. The final questionnaire comprised a total of 54 sentences. It began with two filler sentences, then one experimental sentence, then two more filler sentences, then one experimental sentence, and so on. Sentences were presented in the same order for every participant.[3]

The repeated measures design of this study could have led to some priming effects, unlike in Study 1 which collected only a single measure from each participant in order to avoid priming effects. We tried to limit possible priming in Study 2 by including two fillers between every experimental item, and by not having participants read the sentences aloud (given that reading aloud or repeating stimuli is often used to enhance priming effects).

2. It is theoretically possible that our results could have been influenced by differences in frequency of association between particular nouns and verbs in our items (e.g., McRae et al. 2005). We did not control for such potential frequency differences in our items. However, we do not expect that this had much if any effect since half of the agents and recipients were proper names (which should have no frequency relationship with particular verbs), and since our themes are frequent in general (e.g., *princess, butterfly, frog*) and are not obviously thematically associated with any one of our verbs in particular.

3. An analysis of the effects of the order of presentation of the three sentences for a particular verb did not yield any significant differences in ratings.

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3.1.3 *Procedure*

Participants completed the study online via KwikSurveys in a location of their choice. They first completed a short background questionnaire in which they specified their age, education status, native language, any dialects spoken, and age of beginning to learn a second language. Then they completed the acceptability judgment questionnaire, in which they were given the instructions in (3).

(3) *In diesem Test werden Ihnen deutsche Sätze präsentiert, die Ihnen als deutscher Muttersprachler mal grammatikalisch akzeptabel oder inakzeptabel erscheinen. Ihre Aufgabe besteht darin, die Akzeptabilität dieser Sätze auf der Skala von 1 bis 5 zu bewerten.*
'In this test you will be presented with German sentences which will seem either grammatically acceptable or grammatically unacceptable to you as a German native speaker. Your task is to rate the acceptability of these sentences on a scale of 1 to 5.'

The scale provided with the questions clarified that <1> signified 'absolutely acceptable' while <5> signified 'absolutely unacceptable'. The questionnaire began with six practice items, for which no feedback was provided. Then the 54 test sentences were shown. Participants saw only one sentence at a time on the screen, and were able to move to the next item with no time pressure. They were instructed to rate each sentence as quickly as possible, so that the decision would be as natural and spontaneous as possible. They were not allowed to go back to a previous item once their rating for it was made. The entire procedure took around 20 minutes. All ratings were anonymously stored in a KwikSurveys analysis file and then extracted into SPSS.

3.1.4 *Results*

The mean acceptability ratings for each structure are shown in Figure 4. A one-way repeated measures ANOVA comparing all 6 verbs used in the IOC revealed no difference in ratings [$F(5, 34) = 2.11$, $p = 0.089$]. As expected, these results indicate that the IOC is fully acceptable for all verbs, with ratings of either 1 or 2 ($M = 1.33$, $SD = 0.74$).

One-way within-subject ANOVAs were conducted to compare the acceptability judgements for the three possible structures (IOC, POC with *an*, POC with *zu*) for each verb separately (see Table 3). All six ANOVAs were significant, indicating significant differences among the three conditions for each verb. We therefore computed additional paired-samples t-tests to make pairwise comparisons between the means for each of the three structures, for each verb separately (see Table 4). Note that Table 4 only shows significant differences in acceptability between the different conditions, not whether a particular structure is acceptable

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or unacceptable *per se*. Taken together, the results from Figure 4 (mean ratings) and Table 4 (significant differences between ratings) revealed that each verb except *zeigen* 'show' (accepted only in the IOC) is acceptable in both the IOC and the POC. Whether *an* or *zu* was preferred for the POC depended on the verb.

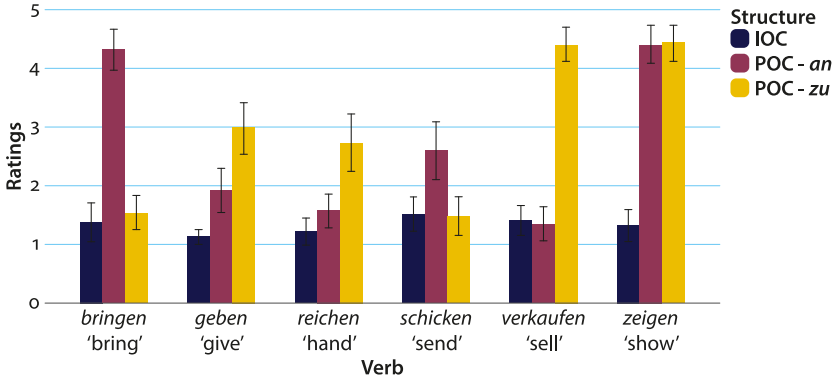

Figure 4. Mean acceptability ratings with error bars (95%) for each verb appearing in the IOC, POC with *an*, or POC with *zu*. The scale ranges from 1 (absolutely acceptable) to 5 (absolutely not acceptable)

Table 3. One-way analysis of variance (ANOVA) comparing the acceptability judgments across the three possible variants (IOC, POC with *an*, POC with *zu*) for each verb

Verb	*SS*	*df*	*MS*	*F*	*p*
bringen 'bring'	211.62	2	105.98	126.42	.000
geben 'give'	63.52	2	31.76	38.82	.000
reichen 'hand'	45.00	1.74	25.80	18.30	.000
schicken 'send'	32.46	1.66	19.57	13.99	.000
verkaufen 'sell'	236.07	2	118.03	192.07	.000
zeigen 'show'	256.11	2	128.06	205.36	.000

Assuming a rating of 3 as the cut off for acceptability (see Figure 4), the data show that the verbs *bringen* 'bring' and *verkaufen* 'sell' were rated as acceptable in the IOC and in only one POC variant (*zu* for *bringen* 'bring' and *an* for *verkaufen* 'sell'). In contrast, *geben* 'give', *reichen* 'hand', and *schicken* 'send' were rated as acceptable in the IOC and in both POC structures, although *post hoc* tests indicated that *an* was significantly preferred over *zu* for *geben* 'give' and *reichen* 'hand', and *zu* was significantly preferred over *an* for *schicken* 'send'. Variability was also somewhat higher for the less preferred POC variant for these three verbs, sug-

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Table 4. Pairwise comparisons (t-tests) of structures for each verb

Verb	Structures compared	*t*	*df*	*p*
bringen (bring)	IOC vs. POC-*an*	14.30	40	.000
	IOC vs. POC-*zu*	1.09	39	.284
	POC-*an* vs. POC-*zu*	−13.50	39	.000
geben (give)	IOC vs. POC-*an*	4.30	39	.000
	IOC vs. POC-*zu*	8.62	40	.000
	POC-*an* vs. POC-*zu*	4.68	39	.000
reichen (hand)	IOC vs. POC-*an*	2.13	40	.039
	IOC vs. POC-*zu*	5.60	40	.000
	POC-*an* vs. POC-*zu*	3.71	40	.001
schicken (send)	IOC vs. POC-*an*	4.26	38	.000
	IOC vs. POC-*zu*	−0.42	38	.680
	POC-*an* vs. POC-*zu*	−4.14	40	.000
verkaufen (sell)	IOC vs. POC-*an*	−0.33	40	.743
	IOC vs. POC-*zu*	15.90	39	.000
	POC-*an* vs. POC-*zu*	16.13	39	.000
zeigen (show)	IOC vs. POC-*an*	15.90	40	.000
	IOC vs. POC-*zu*	17.10	40	.000
	POC-*an* vs. POC-*zu*	0.16	40	.872

gesting a less consistent view of the acceptability of these structures across participants. The lack of a significant difference in acceptability between the IOC and the POC with *zu* for either *bringen* 'bring' or *schicken* 'send', or between the IOC and the POC with *an* for *verkaufen* 'sell', suggests that the IOC and POC variants are perceived as equally acceptable for these verbs. In contrast, the significant difference in acceptability between the IOC and the POC with *an* and *zu* for both *geben* 'give' and *reichen* 'hand' suggests that these two verbs are perceived as most acceptable in the IOC.

3.1.5 *Discussion*

In Study 2, we investigated the acceptability judgments of German native speakers for the IOC, the POC with *an*, and the POC with *zu* for six commonly used ditransitive verbs. All items had animate agents, recipients, and themes. Our first goal was to determine whether the IOC and the POC were judged equally acceptable or whether the IOC had higher ratings for each verb. All verbs were judged

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acceptable in the IOC, and all verbs except *zeigen* 'show' were judged acceptable with at least one POC variant. For three of those verbs, the acceptability ratings were not significantly different for the IOC and the preferred (i.e., *an* or *zu*) POC variant (*bringen* 'bring', *schicken* 'send', *verkaufen* 'sell'). For the other two verbs (*geben* 'give', *reichen* 'hand'), the acceptability ratings were significantly higher for the IOC than for the preferred POC variant. These findings are in line with the literature in that the IOC is fully acceptable for all of our verbs, and is the only or most acceptable structure for three of them (e.g., Dehé 2004; Drenhaus 2004; Meinunger 2006; Callies and Szczesniak 2008; Woods 2012). However, the findings also show that the POC is more acceptable than previously thought, and that it is equally acceptable as the IOC for three of our verbs.

Within this analysis, we focused particularly on patterns for *geben* 'give' and *reichen* 'hand', in order to shed light on controversies in the literature about whether these two verbs can occur with the POC. In line with our hypotheses, we found that all three possible structures – IOC, POC with *an*, and POC with *zu* – were judged acceptable for both verbs, although ratings for the IOC were significantly higher than for both POC variants. Furthermore, ratings for the POC with *an* were significantly higher than for the POC with *zu*. These results contradict claims that German does not allow the dative alternation with core dative verbs such as *geben* 'give' at all (e.g., Sabel 2002: 231; Callies and Szczesniak 2008: 173; Rappaport Hovav and Levin 2008: 162). They also speak against findings from Rappaport Hovav and Levin (2008: 162) who suggest that the *zu* variant of the POC does not occur with *give*-type verbs, and findings from De Vaere, De Cuypere, and Willems (2018: 2) who claim that the POC with *zu* is not appropriate to express transfer with *geben* 'give'. However, our results are consistent with those of Adler (2011: 71–77) who claims that while *geben* 'give' occurs rarely in the POC with *zu*, it can appear in certain contexts associated with custody of the recipient (e.g., *Er gab das Kind zu seinen Eltern* 'He gave the child to his parents' – animate theme; *Er gab das Buch, ein unersetztbarer Familienschatz, zu seinen Eltern* 'He gave the book, which is an irreplaceable family treasure, to his parents' – inanimate theme). It could well be that the acceptability ratings for *geben* 'give' and *reichen* 'hand' in the POC with *zu* (with means of 2.95 and 2.68 respectively) were triggered by the fact that we included only animate constituents in the study, resembling the examples in Adler (2011).

The second research question focused on whether *an* or *zu* was preferred in the POC for each verb. We found that *an* was preferred with *geben* 'give', *reichen* 'hand', and *verkaufen* 'sell', while *zu* was preferred with *bringen* 'bring' and *schicken* 'send'. The preposition *an* was also found acceptable for *schicken* 'send' but with a significantly lower rating, and the same held for *zu* with *geben* 'give' and *reichen* 'hand'. These results are in line with the literature apart from the findings regarding *zu* for *geben* 'give' discussed in the previous paragraph.

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4. General discussion

In this chapter, we aimed to investigate verb biases and metalinguistic acceptability judgments for the POC vs. the IOC in native speakers of German across six commonly used ditransitive verbs: *bringen* 'bring', *geben* 'give', *reichen* 'hand', *schicken* 'send', *verkaufen* 'sell', and *zeigen* 'show'. Most of the previous literature on ditransitive structures in German has focused on the use of canonical vs. non-canonical word order in the IOC, as the IOC is taken to be the default structure in German. It is also largely concerned with qualitative rather than quantitative comparisons, and has primarily focused on whether the two structures have similar or different semantic interpretations (*monosemy* vs. *polysemy* views). It has paid little attention to the POC, or to the lexical preferences of individual verbs for which preposition (*an* or *zu*) is used in the POC. Further, there is considerable controversy in the literature concerning whether the verbs *geben* 'give' and *reichen* 'hand' allow the POC at all, and/or whether the POC with these verbs may be allowed under certain pragmatic, or semantic conditions, or with particle verbs, or in certain dialects of German.

The two studies reported in the present chapter were designed to fill some of these gaps in the literature on the dative alternation in German. The first study, a sentence completion task, asked participants to use the verbs above to describe pictures of events with animate agents and recipients and inanimate themes. The second study, an acceptability judgment task, asked participants to rate the acceptability of sentences containing the verbs above in which all three arguments were animate. These two studies aimed to increase our understanding of speakers' syntactic choices regarding the dative alternation, depending on the verb and the context in which these occur.

The results from the two studies confirmed the well-established finding in the literature that German ditransitives are largely biased towards the IOC, and that some verbs, including *zeigen* 'show', are even restricted to the IOC (e.g., Dehé 2004; Drenhaus 2004; Meinunger 2006; Callies and Szczesniak 2008; Woods 2012). However, our studies also show that the POC is not as uncommon as one might assume from the literature. Participants frequently produced a POC in the sentence completion study (20% of ditransitive responses), and accepted the POC as equally acceptable to the IOC for three of our six verbs (*bringen* 'bring', *verkaufen* 'sell', *schicken* 'send'). These results contradict Wunderlich's (2006: 35) observation that animate recipients trigger the IOC and inanimate recipients trigger the POC in German, since all recipients in both our studies were animate. Finally, we found that the likelihood of producing a POC differs in magnitude across the verbs we analyzed, with a relatively low likelihood for *geben* 'give' and *bringen* 'bring', but a much higher likelihood for *verkaufen* 'sell' and *schicken*

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'send'. The present study is the first to show this spread of structural preferences for the POC vs. the IOC across verbs in German.

A salient question in the literature has focused on the verbs *geben* 'give' and *reichen* 'hand', with some researchers claiming that these verbs are ungrammatical in the POC (e.g., Sabel 2002; Callies and Szczesniak 2008; Rappaport Hovav and Levin 2008) and others claiming that they are grammatical but constrained to particular discourse contexts or dialects (e.g., Dehé 2004; Drenhaus 2004; Liamkina 2008; Adler 2011; Proost 2015; De Vaere, De Cuypere, and Willems 2018). Our results suggest that the POC is indeed grammatical for these verbs, even in situations where the discourse context is relatively neutral. Consistent with other studies, we found that POC productions with *geben* 'give' and *reichen* 'hand' were rare in our sentence completion task – only 3% of productions with *geben* 'give' and no productions with *reichen* 'hand'. However, participants in the acceptability judgment study fully accepted the POC structure for these verbs, albeit with significantly lower ratings than for the IOC, in situations where there was no preceding context of the sort discussed in the literature as prerequisite for the use of the POC (i.e., emphasis on the recipient, in certain semantic senses of the action, when particles are added to the verb which results in a different meaning of the verb; cf. Dehé 2004; Callies and Szczesniak 2008; Liamkina 2008; Adler 2011). Our findings from sentence completion and acceptability judgment tasks thus extend the findings in the literature based on intuition, elicitation, and corpus analysis, and illustrate the importance of considering data from a variety of tasks.

We also analyzed the use of the two prepositions *an* and *zu* for the POC across both the sentence completion and grammaticality judgment tasks. In line with Wegener's (1985) analysis of prepositions used in ditransitive structures, we found more use of *an* than *zu* across the verbs that allowed the POC taken together. However, we found that the verbs exhibited individual preferences. The verbs *geben* 'give', *reichen* 'hand' and *verkaufen* 'sell' showed a preference for *an* across both tasks, while *bringen* 'bring' showed a preference for *zu* across both tasks, and *schicken* 'send' showed different preferences across the tasks: *an* for the sentence completion task and *zu* for the grammaticality judgment task. Further, results for both *bringen* 'bring' and *verkaufen* 'sell' showed no evidence that the alternative preposition was acceptable at all (though the Bayesian analysis left open the possibility that it might be used in the general population), while results for both *geben* 'give' and *reichen* 'hand' showed that the alternative preposition was fully acceptable albeit less preferred. Our results do not support claims in the literature that the POC with *zu* is not possible with *geben* 'give' (Rappaport Hovav and Levin 2008), but are consistent with claims that this can occur in restricted semantic contexts (Adler 2011; De Vaere, De Cuypere, and Willems 2018). Some literature has investigated the slight semantic differences that *an* vs. *zu* can trigger in

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the interpretation of individual verbs. For example, although *geben* 'give' is most commonly used with *an*, *zu* can be used to express a custody relationship (Adler 2011: 71–77). Since our study did not investigate such semantic differences, we can shed no light on this discussion.

A particularly interesting finding is the difference in preference for *an* vs. *zu* for the verb *schicken* 'send', depending on the task. We suspect that this must have come at least partially from the difference in animacy of the theme across the two studies. According to Adler (2011), the preposition *an* implies an addressee meaning in that the theme is moved by someone to the goal, whereas *zu* entails a directional meaning in that the theme moves by itself to the goal. This entails that for *an*, the theme must be inanimate in order to be moved, which was indeed the case in our sentence completion task. Similarly, for *zu*, the theme must be animate in order to move itself, which was also the case in our acceptability judgment task. Although our items in the latter task did not explicitly convey that the theme moved by itself, it is of course possible that participants interpreted some items in that way (*Der Zauberer schickte den Frosch zu der Meerjungfrau* 'The magician sent the frog to the mermaid', *Der Prinz schickte die Katze zu der Prinzessin* 'The prince sent the cat to the princess', *Kirsten schickte den Schmetterling zu Horst* 'Kirsten sent the butterfly to Horst'). In contrast to Adler (2011), Proost (2015: 19) and De Vaere, De Cuypere, and Willems (2018: 2) state that *schicken* 'send' can be used with both *an* and *zu* to entail the meaning of transfer to a recipient, and do not distinguish between change of location and change of possession like Adler does. It would be interesting to test the competing claims of Adler (2011) vs. De Vaere, De Cuypere, and Willems (2018) and Proost (2015) more extensively in an acceptability judgment task with more items that are explicitly manipulated for the relevant factors.

Finally, our results highlight the value of considering different types and modalities of data in analyzing structural preferences, consistent with previous findings from Kempen and Harbush (2005) and from Bresnan and Nikitina (2008). As these authors have noted, each type of data reveals a different part of the full picture, so focusing on only one or the other might lead to a more restricted view of structural preferences than is warranted. For example, certain structures may appear rarely in production tasks due to structural bias or frequency effects, although those same structures are classified as fully acceptable on receptive tasks (see Gries 2005).

Two results from our studies were particularly enlightening in illustrating the need for multiple approaches. First, the POC was rare (*geben* 'give', *bringen* 'bring') or absent (*reichen* 'hand') for three of the verbs in the sentence completion task, but rated as fully acceptable in the grammaticality judgment task. For the other three verbs, the level of production and acceptance for the POC

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structure was similar across the two tasks: frequently used and fully accepted for *verkaufen* 'sell' and *schicken* 'send' vs. never produced and rated as ungrammatical for *zeigen* 'show'. Second, we found diverging preferences for the two possible prepositions in the POC structure for *schicken* 'send' across the two studies: *an* was preferred in the sentence completion task while *zu* was preferred in the acceptability judgment task. Looking at either the productive or receptive task alone would have yielded an incomplete understanding of the structural preferences for these verbs.

Similar cross-task effects have been shown previously for the German ditransitive by Kempen and Harbush (2005) in their assessment of preferences for linear ordering of the IOC (i.e., recipient-theme vs. theme-recipient order) in various conditions. They found that several structures that were never or rarely produced in their own production tasks were nonetheless judged as fully grammatical in a grammaticality judgment task conducted by Keller (2000), suggesting that metalinguistic judgements indicate a greater freedom of word order than production data do. Kempen and Harbusch (2005) hypothesized that there is a critical value or 'production threshold' on grammaticality rating scales, such that structures rated well above the threshold usually occur in corpora with moderate to high frequencies, while structures rated slightly above or below the threshold hardly ever occur in production (structures with very low values typically appear only as production errors). This is consistent with our results to some degree. If we take the critical value on our scale as 3 (halfway between the endpoints 1 and 5), then the values for the POC with *zu* for both *geben* 'give' (2.98) and *reichen* 'hand' (2.69) are just below the threshold, and these structures appeared rarely or not at all in our production task. Further, the structures that were rated well below the critical value on our acceptability judgment task never appeared in our production task, and all but one of the structures that were rated well above the critical value were used frequently in our production task. However, there are also some exceptions. First, the value for *schicken* 'send' in the POC with *an* (2.57) is just below the threshold on the receptive task, but this structure was produced very frequently in our sentence completion task. Second, *geben* 'give' occurred in the POC with *an* in only 2% of the ditransitive sentence completion responses but its score on the acceptability judgment task was well above the threshold (1.93). Thus, we suggest that further research is necessary to fully understand the relationship between structural preferences on production vs. reception tasks. The role of different contextual factors including animacy is likely to be relevant here.

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5. Conclusion

This chapter has reported on two empirical investigations of structural verb bias effects across six commonly used ditransitive verbs in German. Our findings support the literature in showing that the IOC is produced and accepted for all the verbs under study. More importantly, our findings extend the literature in showing that the POC is judged fully acceptable for five of the six verbs including *geben* 'give' and *reichen* 'hand', which have often been categorized in the literature as non-alternating. We further show that the five verbs that allow the POC differ substantially in their degree of preference for either the IOC or the POC, and that one of these five verbs (*schicken* 'send') was biased towards the POC in the sentence completion task. The verbs also differ in their preference for preposition use in the POC: three verbs preferred the preposition *an*, one preferred *zu*, and one allowed both. Using two different modalities for the empirical studies (sentence completion and grammaticality judgment) was essential for obtaining a broader understanding of the structural preferences that one method would not have provided on its own. In particular, one verb (*reichen* 'hand') was not produced with the POC but was judged fully acceptable with that structure, and one verb (*schicken* 'send') was used preferentially with *an* in the sentence completion task but was preferred with *zu* in the grammaticality judgment task. Such tasks requiring different skills – e.g., production vs. reception – are helpful in that each may reveal patterns that are hidden in other domains. Overall, we conclude from these two studies that POCs are an essential part of the German language and merit more detailed investigation.

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Appendix

Sentence completion study

Verb	Agent	Theme	Recipient
geben 'give'	*der Polizist* 'the police officer'	*die Blume* 'the flower'	*die Frau* 'the woman'
	das Mädchen 'the girl' *der Opa* 'the grandfather'	*der Ball* 'the ball'	*der Junge* 'the boy'
		das Geschenk 'the present'	*das Kind* 'the child'
	der Junge 'the boy'	*das Geschenk* 'the present'	*das Mädchen* 'the girl'
bringen 'bring'	*die Katze* 'the cat'	*die Hausschuhe* 'the slippers'	*der Besitzer* 'the owner'
	der Hase 'the rabbit'	*der Korb* 'the basket'	*die Oma* 'the grandmother'
	die Krankenschwester 'the nurse'	*die Medizin* 'the medicine'	*die Patientin* 'the patient'
	das Mädchen 'the girl'	*der Ball* 'the ball'	*der Junge* 'the boy'
reichen 'hand'	*das Mädchen* 'the girl'	*der Ball* 'the ball'	*der Junge* 'the boy'
	der Junge 'the boy'	*der Luftballon* 'the balloon'	*die Frau* 'the woman'
	die Frau 'the woman'	*der Lollipop* 'the lollipop'	*der Junge* 'the boy'
	der Postbote 'the postman'	*der Brief* 'the letter'	*der Mann* 'the man'
schicken 'send'	*das Mädchen* 'the girl'	*der Brief* 'the letter'	*die Oma* 'the grandmother'
	das Mädchen 'the girl'	*der Brief* 'the letter'	*der Weihnachtsmann* 'Santa Claus'
	das Mädchen 'the girl'	*die Blumen* 'the flowers'	*die Oma* 'the grandmother'
verkaufen 'sell'	*die Frau* 'the woman'	*der Teddybär* 'the teddy bear'	*der Junge* 'the boy'
	die Frau 'the woman'	*die Blume* 'the flower'	*der Mann* 'the man'
	der Clown 'the clown'	*der Luftballon* 'the balloon'	*das Mädchen* 'the girl'
	der Mann 'the man'	*das Buch* 'the book'	*die Frau* 'the woman'
zeigen 'show'	*der Clown* 'the clown'	*der Luftballon* 'the balloon'	*der Junge* 'the boy'
	der Lehrer 'the teacher'	*die Karte* 'the map'	*die Schüler* 'the pupils'

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Verb	Agent	Theme	Recipient
	das Mädchen 'the girl'	*der Ball* 'the ball'	*der Junge* 'the boy'
	der Junge 'the boy'	*das Geschenk* 'the present'	*das Mädchen* 'the girl'

Acceptability judgement study

Item		Verb	DO/ PO	German	English
1.	1	geben	DO	Der König gab der Königin das Baby.	The king gave the queen the baby.
	2	geben	PO – an	Der König gab das Baby an die Königin.	The king gave the baby to the queen.
	3	geben	PO – zu	Der König gab das Baby zu der Königin.	The king gave the baby to the queen.
2	1	geben	DO	Petra gab Hans die Maus.	Petra gave Hans the mouse.
	2	geben	PO – an	Petra gab die Maus an Hans.	Petra gave the mouse to Hans.
	3	geben	PO – zu	Petra gab die Maus zu Hans.	Petra gave the mouse to Hans.
3	1	geben	DO	Der Ritter gab der Frau das Kind.	The knight gave the woman the child.
	2	geben	PO – an	Der Ritter gab das Kind an die Frau.	The knight gave the child to the woman.
	3	geben	PO – zu	Der Ritter gab das Kind zu der Frau.	The knight gave the child to the woman.
4	1	bringen	DO	Klara brachte Lars den Hasen.	Klara brought Lars the rabbit.
	2	bringen	PO – an	Klara brachte den Hasen an Lars.	Klara brought the rabbit to Lars.
	3	bringen	PO – zu	Klara brachte den Hasen zu Lars.	Klara brought the rabbit to Lars.
5	1	bringen	DO	Opa brachte der Oma den Papagei.	Grandfather brought the grandmother the parrot.
	2	bringen	PO – an	Opa brachte den Papagei an die Oma.	Grandfather brought the parrot to the grandmother.
	3	bringen	PO – zu	Opa brachte den Papagei zu der Oma.	Grandfather brought the parrot to the grandmother.
6	1	bringen	DO	Stefan brachte Sabine das Eichhörnchen.	Stefan brought Sabine the squirrel.
	2	bringen	PO – an	Stefan brachte das Eichhörnchen an Sabine.	Stefan brought the squirrel to Sabine.
	3	bringen	PO – zu	Stefan brachte das Eichhörnchen zu Sabine.	Stefan brought the squirrel to Sabine.

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Item		Verb	DO/ PO	German	English
7.	1	reichen	DO	Der Junge reichte dem Mädchen den Fisch.	The boy handed the girl the fish.
	2	reichen	PO – an	Der Junge reichte den Fisch an das Mädchen.	The boy handed the fish to the girl.
	3	reichen	PO – zu	Der Junge reichte den Fisch zu dem Mädchen.	The boy handed the fish to the girl.
8	1	reichen	DO	Anika reichte Christian die Schildkröte.	Anika handed Christian the turtle.
	2	reichen	PO – an	Anika reichte die Schildkröte an Christian.	Anika handed the turtle to Christian.
	3	reichen	PO – zu	Anika reichte die Schildkröte zu Christian.	Anika handed the turtle to Christian.
9	1	reichen	DO	Vanessa reichte Werner den Marienkäfer.	Vanessa handed Werner the ladybeetle.
	2	reichen	PO – an	Vanessa reichte den Marienkäfer an Werner.	Vanessa handed the ladybeetle to Werner.
	3	reichen	PO – zu	Vanessa reichte den Marienkäfer zu Werner.	Vanessa handed the ladybeetle to Werner.
10	1	schicken	DO	Der Prinz schickte der Prinzessin die Katze.	The prince sent the princess the cat.
	2	schicken	PO – an	Der Prinz schickte die Katze an die Prinzessin.	The prince sent the cat to the princess.
	3	schicken	PO – zu	Der Prinz schickte die Katze zu der Prinzessin.	The prince sent the cat to the princess.
11	1	schicken	DO	Kirsten schickte Horst den Schmetterling.	Kirsten sent Horst the butterfly.
	2	schicken	PO – an	Kirsten schickte den Schmetterling an Horst.	Kirsten sent the butterfly to Horst.
	3	schicken	PO – zu	Kirsten schickte den Schmetterling zu Horst.	Kirsten sent the butterfly to Horst.
12	1	schicken	DO	Der Zauberer schickte der Meerjungfrau den Frosch.	The magician sent the mermaid the frog.
	2	schicken	PO – an	Der Zauberer schickte den Frosch an die Meerjungfrau.	The magician sent the frog to the mermaid.
	3	schicken	PO – zu	Der Zauberer schickte den Frosch zu der Meerjungfrau.	The magician sent the frog to the mermaid.
13	1	zeigen	DO	Sarah zeigte Klaus den Welpen.	Sarah showed Klaus the puppy.
	2	zeigen	PO – an	Sarah zeigte den Welpen an Klaus.	Sarah showed the puppy to Klaus.

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Item		Verb	DO/ PO	German	English
	3	zeigen	PO – zu	Sarah zeigte den Welpen zu Klaus.	Sarah showed the puppy to Klaus.
14	1	zeigen	DO	Die Lehrerin zeigte dem Schüler den Vogel.	The teacher showed the pupil the bird.
	2	zeigen	PO – an	Die Lehrerin zeigte den Vogel an den Schüler.	The teacher showed the bird to the pupil.
	3	zeigen	PO – zu	Die Lehrerin zeigte den Vogel zu dem Schüler.	The teacher showed the bird to the pupil.
15	1	zeigen	DO	Thomas zeigte Corinna das Pony.	Thomas showed Corinna the pony.
	2	zeigen	PO – an	Thomas zeigte das Pony an Corinna.	Thomas showed the pony to Corinna.
	3	zeigen	PO – zu	Thomas zeigte das Pony zu Corinna.	Thomas showed the pony to Corinna.
16	1	verkaufen	DO	Der Bauer verkaufte der Dame die Ente.	The farmer sold the lady the duck.
	2	verkaufen	PO – an	Der Bauer verkaufte die Ente an die Dame.	The farmer sold the duck to the lady.
	3	verkaufen	PO – zu	Der Bauer verkaufte die Ente zu der Dame.	The farmer sold the duck to the lady.
17	1	verkaufen	DO	Die Hexe verkaufte dem Zwerg die Fledermaus.	The witch sold the dwarf the bat.
	2	verkaufen	PO – an	Die Hexe verkaufte die Fledermaus an den Zwerg.	The witch sold the bat to the dwarf.
	3	verkaufen	PO – zu	Die Hexe verkaufte die Fledermaus zu dem Zwerg.	The witch sold the bat to the dwarf.
18	1	verkaufen	DO	Gisela verkaufte Michael das Küken.	Gisela sold Michael the chick.
	2	verkaufen	PO – an	Gisela verkaufte das Küken an Michael.	Gisela sold the chick to Michael.
	3	verkaufen	PO – zu	Gisela verkaufte das Küken zu Michael.	Gisela sold the chick to Michael.

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4.3 Discussion

The work presented in Chapter 4 served to explore acquisition patterns of ditransitive verbs and their realizations in double object vs. prepositional object structures in German-speaking children and the usage patterns, as well as the extent to which these verbs are acceptable in the two structures in German-speaking adults. More specifically, this work aimed to provide insights into the following: 1) the acquisition patterns of ditransitive verbs and the developmental trajectory associated with their use; 2) the frequency with which these verbs occur in child and adult speech, as well as the structures used or accepted with them; 3) structural verb bias effects and the overall language bias toward ditransitive structures; and 4) the use of prepositions within PO constructions, including the extent to which scrambled word order is possible.

In Study 1, we used a corpus-based approach and extracted tokens of structures with seven ditransitive verbs in five German-speaking children aged 1;6–7;5. These verbs were found to emerge in the period 2;0 – 2;11. The verbs *geben* 'give',*zeigen* 'show', and *bringen* 'bring' emerged first and were most frequent, whereas *reichen* 'hand', *schicken* 'send', *verkaufen* 'sell', and *werfen* 'throw' were produced more rarely. The relative frequency of use of these verbs at the youngest ages was maintained across growing age. The DO was clearly the most widely used and well-established structure for both children and adults. In children, the first complete DO constructions emerged around age 2;0 – 2;11 for the verb *geben* 'give' (N=20) followed by *zeigen* 'show' (N=7), with a few DO productions for the other verbs. We observed very scarce use of PO structures in both children (1% of total productions of ditransitive structures) and adults (2,7 % of total productions of ditransitive structures. Although, these results provided valuable information about structural development in language acquisition, especially with particular verbs, we were still not able to answer questions with respect to the alternation likelihood of verbs such as *geben* 'give' and *reichen* 'hand' as well as *zeigen* 'show' (not supposed to alternate) or *verkaufen* 'sell' due to very low token frequency.

For these reasons, we further examined patterns in dative alternation structures using two methods: a sentence completion task in which adults described a ditransitive action by using the structure of their choice, and a grammaticality judgement task which elicited acceptability ratings for both DO and PO structures together with the two prepositions accompanying POs. Importantly, all experimental items elicited the production or rating of full NPs (lexical nouns or proper names) for agents and recipients. The results confirmed prior claims and our corpus observations that the verb *zeigen* 'show' is restricted to the DO

construction. While *geben* ('give') and *reichen* ('hand') showed little to no PO use in both the sentence completion task and corpus data, the acceptability study provided evidence that PO constructions with *an* are still judged grammatical for both verbs. These findings challenge existing claims that these verbs occur in PO structures only in dialectical forms or for emphasis (Drenhaus, 2004; Liamkina, 2008). Importantly, the data suggest overall that POs are more frequent in German than has been documented in prior studies, challenging prior assumptions in the literature. Further, the sentence completion results revealed that the biases across the verbs under investigation are spread unevenly in proportions, as the verbs *werfen* 'throw' and *verkaufen* 'sell' are used with POs quite often compared to *bringen* 'bring' and *geben* 'give'. Furthermore, the verb *schicken* 'send' is largely PO-biased. It follows that speakers' preference for using PO vs. DO in an individual sentence depends at least partly on the verb's bias, and that presumably more verbs in German could be found to be biased towards the PO construction. This finding serves as a basis for further investigation into the contexts and conditions under which POs may arise, seeking to refine and expand current linguistic assumptions. We also found that, in line with the corpus analysis, scrambling with full lexical NP arguments appeared very rarely, suggesting a robust representation of the NP_V_NP$_{DAT}$_NP$_{ACC}$ structure in German speakers.

As noted earlier, we provided empirical evidence in both our child corpora and experimental studies for the existence of the PO structure with verbs that the literature claims are almost never used in the PO construction. We conclude from this analysis that POs are an essential part of the language and should be studied more thoroughly. Furthermore, the results signal that the modality in which language is observed is an important factor for the interpretation of results. Depending on whether the task requires production or receptive skills, results might reveal non-converging patterns or might help to uncover patterns that were not visible in other tasks.

The preceding studies on the dative alternation played a pivotal role in shaping the design of the items utilized in the priming studies reported in Chapter 5, ensuring that the verbs included in the priming design were representative of actual language use and the extent to which alternative structural choices are possible. According to these results, we decided to use four alternating verbs in the priming paradigm: *geben* 'give'*, bringen* 'bring'*, schicken* 'send' and *verkaufen* 'sell'. Although the bias strength towards the PO is very different among the four verbs, they were clearly found to alternate and to be used in the population. The other verbs that we studied were not appropriate for our design. *Zeigen* 'show' was found to be restricted to the DO only, while *reichen* 'hand' was found to be extremely unfamiliar to

children. *Werfen* ‘throw’ does not appear alone in ditransitives but rather requires the particle *zu* in the DO structure – e.g., *Der Junge wirft dem Mädhchen den Ball zu* ‘The boy throws the girl the ball’. This is effectively a verb containing a particle - *zu+werfen* - and was regularly used by German-speaking adults in the sentence completion study.

The connection established between prior work and the actual priming design provided the basis for the upcoming hypotheses and expectations about the behaviour of children and adults in the priming experiment. In Chapter 5, we will introduce the main questions and design of the experiment by taking into account the knowledge of the dative alternation we gained from the studies in Chapter 4

Chapter 5: Structural Priming Studies in Monolinguals and Bilinguals

In the current chapter, we present two articles on structural priming in children and adults. The first article on priming in monolingual German-speaking children is published in the peer-reviewed journal *Languages 8*(4) in 2023 (doi: 10.3390/languages8040264). The second article on structural priming in German-speaking bilingual children has been submitted to the peer-reviewed journal *Journal of Child Language* and is currently under revision.

Before presenting the articles themselves, we present a concise summary of the main gaps and our research questions based on the knowledge obtained from all previous chapters. Specifically, we identify primary gaps in the existing literature on priming (introduced in Chapter 2) and the DA in German (introduced in Chapter 3), including the fundamental insights derived from our studies on the dative alternation (DA) in German (Chapter 4). In contrast to the introduction in Chapter 1, where we identify individual research questions for the monolingual vs. the bilingual children accompanied with more elaborated hypotheses for each question, this summary serves to remind the reader about the objectives of the upcoming priming experiments from a wider perspective taking in a broader picture of the relevant literature and the outcomes from the pre-studies.

5.1 Identifying the gaps

Structural priming has emerged as a robust diagnostic tool for evaluating abstract representations in both children and adults. More specifically, it is assumed that when a structure that has been just heard or used is reproduced in a subsequent utterance (or written production), irrespective of any lexical material among the two structures, humans possess an abstract representation of this structure, resulting in a faciliatory repetition effect. The assertion that humans would not exhibit a priming effect if they relied solely on item-specific representations provides a critical insight into the cognitive processes underlying language use. This implication suggests that a more complex representation system must be at play, allowing for the activation of broader linguistic structures and associations. For these reasons, many priming studies dedicated to children examined the extent of abstractedness in children by applying a priming methodology, which contributed to our understanding of language acquisition processes. Besides *abstract priming effects*, research conducted over the past four decades has yielded numerous insights into various supplementary effects such as the *lexical boost effect*, *surprisal* and *cumulative priming*; however, these findings have primarily

emerged from the adult priming literature. An increase in the reproduction of a primed structure is not only observed at the abstract level (when the prime and the target do not share any lexical items) but is enhanced even more when the prime and the target share the same verb (*lexical boost effect*). Priming effects can be observed both immediately between prime and target pairs and across time as *cumulative effects* built across increasing trials throughout a priming session. Such effects have been documented as adaptation effects resulting from the accumulation of experiences, which are proposed to persist throughout the lifespan, thereby suggesting the presence of implicit learning. This theory, received the name *Implicit Learning* and suggests that such adaptation effects are primarily caused by sensitivity to distributional patterns in the language; that is, the less frequently used construction in the population is most likely to cause a slight bias towards the same structure being reproduced immediately or with accumulating input. The theory is grounded on predictive mechanisms engaged during the processing of syntactic input. Whenever our processor fails to accurately predict an upcoming word (*prime surprisal*), our system adapts to the error by allowing the system to integrate this experience and apply a recalibration of expectations regarding language input. The next time the speaker is exposed to the same structure in the input, the system's prediction will contain a slightly higher probability of expecting this structure than before. This incremental adjustment reflects a learning process that improves expectations regarding upcoming syntactic realizations with each linguistic experience, leading to a continuous overwriting process of existing representations.

Crucially, the priming effects observed in adult literature underline the necessity to explore these phenomena in children's language processing because it is plausible that priming effects may differ significantly from those found in adults. Such differences could provide valuable insights into the dynamics of language acquisition and structural comprehension as they evolve. Another notable gap pertains to the lack of priming studies with bilingually raised children who receive less input in a given language than monolingually raised children receive. Although there are some studies on priming effects within one language of bilingual children, effects such as the *lexical boost*, *cumulative priming* and *surprisal* are understudied. Understanding how these effects evolve in the linguistic environment of a bilingual child may ultimately enrich existing theories of early bilingual acquisition. In the two priming articles with monolingually and bilingually raised children provided in this chapter, we attempt to fill these gaps in the literature by using a developmental approach in a language that is structurally different from English in the probability distribution of the dative alternation. In pursuit of understanding priming behavior

across development, we investigate children across several stages of their linguistic development to identify any changes that occur as children grow older. The potential influence of the structural typology of the target language on priming behavior has not yet received adequate attention in the child literature. Previous studies have largely aimed to establish evidence for or against the existence of abstract structural representations, neglecting the probabilistic aspects that govern structural typology in child language because the research was mainly conducted in English. The German dative alternation offers a unique opportunity to study priming effects due to the relative rarity of prepositional object (PO) structures, which differentiates it from languages like English where both alternatives of the DA are used relatively frequently.

To achieve our research objectives, we developed several pre-studies in which we closely examined the usage patterns of common ditransitive verbs and the probabilistic distribution with which each of the alternative structures occurs in child and adult production and comprehension, providing foundational data for understanding how these verbs function regarding the choice of a ditransitive structure. Although the results supported a widely discussed observation in the literature that German is heavily DO-biased, there was evidence that particular verbs take the PO alternate much more often than previously documented in the literature. Based on our observations, we chose four verbs for implementation in the priming study that showed varied probabilities for the PO structure in increasing order: *geben* 'give' was highly biased to the DO but allowed some use of the PO, *bringen* 'bring' allowed somewhat more use of the PO structure, *verkaufen* 'sell' was biased towards the DO but much less than the previous two verbs, and *schicken* 'send' was found to be even slightly biased towards the PO (at least in adults). Although the study was not designed to examine priming effects as a function of particular verbs, it allowed for this type of supplementary analysis on an exploratory level. The average of the biases for all four verbs is approximately 20% PO bias. This established bias creates a satisfactory balance for our research purposes. The idea is that since at least two verbs were used relatively often in the PO structure, children should have some representation for them. Although the other two verbs were used less frequently in the PO structure, they were frequently used in child and child-directed speech, so we assumed that children would be able to generalize the PO dative under primed conditions across all four verbs. Importantly, we incorporated a baseline in our priming experiment prior to the priming procedure to gain more insights into the structural preferences of the target children and adults involved in the experiment.

In this section, we provide a brief overview of the core research questions central to our investigation, which have been elaborated upon in Chapter 1, where their underlying motivations and theoretical framework are thoroughly examined. Here, we aim to reiterate their core elements briefly, highlighting their crucial role in guiding the direction of our research.

First, we were interested in the initial biases that children possess for DO vs. PO structures across several age groups and expected at least some PO productions (more than previously observed in child corpora) due to elicited production (via cartoons containing ditransitive actions). Since there is little information available in the literature on the ditransitive realizations in bilingually raised children (other than a few studies suggesting a general PO bias in bilinguals and a study by Schönenberger et al. (2011) who observed more POs in German-Turkish speaking bilingual children compared to German monolingual children), we were interested whether bilingual children would be sensitive to the bias of the target language and whether they would also be likely to tend to use the PO structure more in a language with a heavy DO bias.

Second, we examined how structural priming would affect children immediately and across increasing trials compared to the baseline and whether both groups possess abstract syntactic representations from as early as three years of age. We aimed to expand upon the existing priming literature in children by investigating a language that provides relatively few instances of the PO alternate in the child's linguistic environment. This structural feature may constrain the development of abstract representations and could potentially result in no priming. There may be a threshold for linguistic experiences to trigger priming effects, especially in bilingual children who possess multiple language systems. However, if children possess a sufficient number of experiences, they should exhibit priming effects and adapt effectively with increasing input (suggesting learning), which may be even greater than found for English-speaking children, due to greater prediction error and greater surprisal for the primed structure (predicted by the *Implicit Learning Theory*). *Surprisal effects* are predicted for all participants due to the strong DO bias of the language; however, these effects may be particularly pronounced in participants whose structural representations are less robust (e.g., young children, bilinguals).

Third, our objective was to investigate the development of the lexical boost effect. This phenomenon has been shown to induce significantly enhanced priming effects in the adult literature. However, its role in the context of child priming remains ambiguous, as some studies report similar findings while others do not. The Implicit Learning Account posits that

the lexical boost effect should develop with growing age because it is related to a distinct mechanism within working memory – one that is known to strengthen with age. If this assumption is true, both monolingual and bilingual child groups should show the lexical boost at older ages, given that this phenomenon is not contingent upon linguistic properties present in the input and pertains to fundamental language-independent cognitive abilities. The ability to learn statistical occurrences implicitly from early on is considered to provide the foundations for the acquisition of syntax in usage-based theories of language acquisition (Bannard et al., 2009; Chang et al., 2008; Kidd et al., 2010). Hence, we included an additional age group of 7- to 8-year-old children, which was not previously studied in ditransitive priming studies. Since 3- to 4-year-old children showed no lexical boost effect in Rowland et al. (2012) and Peter et al. (2015), and 5- to 6-year-old children showed only a numerical trend towards the lexical boost effect, we hypothesized that the lexical boost effect is likely to be more visible in 7- to 8-year-old children.

Finally, we explore whether any priming effects (if present) in bilingual children are influenced by the structural properties of their other language. Consistent with recent findings in the bilingual adult priming literature, which suggest minimal interference from the first language (L1) onto the second language (L2) at high levels of proficiency, and with evidence that bilingual children also use their languages in a largely language-specific manner—reflecting patterns similar to monolingual acquisition—we hypothesize that any such effects, if present, will be minimal.

5.2 Publication 2

Kholodova, A., Peter, M., Rowland, C. F., Jacob, G., & Allen, S. E. M. (2023). Abstract priming and the lexical boost effect across development in a structurally biased language. *Languages, 8*(4), 264. https://doi.org/10.3390/languages8040264

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Abstract Priming and the Lexical Boost Effect across Development in a Structurally Biased Language

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Abstract: The present study investigates the developmental trajectory of abstract representations for syntactic structures in children. In a structural priming experiment on the dative alternation in German, we primed children from three different age groups (3–4 years, 5–6 years, 7–8 years) and adults with double object datives (Dora sent Boots the rabbit) or prepositional object datives (Dora sent the rabbit to Boots). Importantly, the prepositional object structure in German is dispreferred and only rarely encountered by young children. While immediate as well as cumulative structural priming effects occurred across all age groups, these effects were strongest in the 3- to 4-year-old group and gradually decreased with increasing age. These results suggest that representations in young children are less stable than in adults and, therefore, more susceptible to adaptation both immediately and across time, presumably due to stronger surprisal. Lexical boost effects, in contrast, were not present in 3- to 4-year-olds but gradually emerged with increasing age, possibly due to limited working-memory capacity in the younger child groups.

Keywords: structural priming across development; dative alternation; lexical boost; cumulative priming

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1. Introduction

A key question in developmental psycholinguistics is how abstract representations for syntactic structures develop in children and how such representations are integrated into the wider human language processing system. Within this field of research, a substantial number of studies have convincingly shown that children already possess abstract syntactic representations by the age of three or earlier (Bencini and Valian 2008; Branigan and McLean 2016; Gámez and Shimpi 2015; Huttenlocher et al. 2004; Kidd 2012a, 2012b; Messenger et al. 2011; Rowland et al. 2012; Shimpi et al. 2007; Thothathiri and Snedeker 2008a, 2008b). However, only relatively few studies have investigated how these abstract syntactic representations, once established, develop further with increasing age. Also, the potential role of particular linguistic properties of a specific syntactic structure, such as its frequency within the language, is not yet fully understood. It is these issues we focus on in the present study.

An effective methodological approach to studying the nature of syntactic representations in human beings is based on the phenomenon of structural priming, i.e., a speaker's tendency to re-use structures previously encountered (e.g., Bock 1986; Bock and Loebell 1990; Branigan et al. 2000a; Pickering and Branigan 1998). For example, after hearing a prime sentence with a prepositional-object (henceforth, PO) structure (e.g., *The waitress brought a tray of appetizers to the customers*), adult speakers are more likely to produce a PO sentence (e.g., *The woman gave the letter to the lawyer*) than an otherwise identical prime sentence with a double-object (DO) structure (e.g., *The waitress brought the customers a tray*

of appetizers). In experimental psycholinguistic research, structural priming effects can be used as a tool to gain insight into the nature of the syntactic representations involved in language processing and production. If a participant group shows structural priming effects, this can be considered evidence for abstract syntactic representations.

While it is largely uncontroversial that children already show structural priming effects by the age of three, several issues related to key observations from child priming studies remain unresolved. For instance, the results from such studies differ very considerably with respect to the *lexical boost effect*, i.e., the fact that priming effects tend to be stronger when prime and target share the same head verb. Studies investigating structural priming in adults show robust evidence for such lexical boost effects (e.g., Cleland and Pickering 2003; Gries 2005; Hartsuiker et al. 2008; Pickering and Branigan 1998; see Carminati et al. 2019 for a comprehensive review). In the adult literature, these effects are typically interpreted with reference to connections between abstract structural representations and lexical entries for verbs, which can serve as the head of the respective structure (see Pickering and Branigan 1998; van Gompel et al. 2023). For children, lexical boost effects have been subject to considerable debate. While some child priming studies found similar lexical boost effects as in adults (Branigan and McLean 2016; Morris and Scheepers 2015; Messenger and Hardy 2017), other studies did not but showed some numerical indication toward an increase of the lexical boost with growing age (Peter et al. 2015; Rowland et al. 2012; Thothathiri and Snedeker 2008b). Further, in a recent longitudinal study investigating priming for the active/passive alternation in English (Kumarage et al. 2022), children at the age of 36 months already showed significant abstract structural priming but no lexical boost effect. Instead, the lexical boost effect only gradually developed with increasing age, with the same children showing a robust lexical boost at 54 months of age. These results suggest that the lexical boost effect might be attributed to the development of working memory. The existing studies investigating the lexical boost in children differ substantially with regard to a wide range of potentially important properties, such as the experimental task, language, and type of structural alternation investigated, and whether they have looked at priming effects in production or comprehension.

Another key finding is that, in adults, exposure to more than one prime sentence with the same structure causes stronger priming, a finding known as the *cumulative priming effect* (e.g., Bock and Griffin 2000; Bock et al. 2007; Hartsuiker et al. 2008; Huttenlocher et al. 2004; Kaschak et al. 2011). While cumulative priming is discussed with reference to implicit learning and adaptation to external input (e.g., Jaeger and Snider 2008, 2013; Kaan and Chun 2018; Kaschak and Borreggine 2008; Kaschak et al. 2011)[1], cumulative priming effects in children have mainly been found in blocked designs (Gámez and Shimpi 2015; Huttenlocher et al. 2004; Kidd 2012a, 2012b; Savage et al. 2003, 2006; Serratrice et al. 2015) in which children were primed with one structural option throughout one session. To our knowledge, only three studies (Branigan and McLean 2016; Messenger 2021; Messenger et al. 2011) have tried to disentangle immediate and cumulative priming effects in an experimental design based on prime–target pairs within a single test session. However, the results from these studies are mixed and show inconsistent patterns.

Finally, prime sentences with infrequent, rarely encountered structures typically cause stronger priming, a finding referred to as *inverse frequency effect* (see Fine et al. 2013) or *prime surprisal* (see Jaeger and Snider 2008; Scheepers 2003). Peter et al. (2015) report the results from a PO/DO priming study in which they experimentally manipulated verb bias. Children showed stronger priming effects when the prime contained a verb in an unexpected structure. This effect was stronger in children than in adults, suggesting that surprisal effects may generally be enhanced in children.

1.1. Theoretical Accounts of Structural Priming

Several theoretical accounts trying to explain the underlying mechanisms of language processing and production responsible for structural priming effects have been proposed. *Residual Activation Accounts* (e.g., Pickering and Branigan 1998), for example, explain structural priming through the activation of stored, abstract representations for syntactic

structures (called *combinatorial nodes*) situated at the lemma stratum. These structural representations are activated during the processing of a prime sentence. Residual activation of this representation subsequently influences structural choices during the production of a target, causing structural priming. Additionally, Residual Activation Accounts assume connections between structural representations and the lexical representations of verb lemmas, which can be used as the head of the particular structure. When prime and target contain the same verb, activation spreads through these connections. This leads to increased activation of the respective combinatorial node, causing a lexical boost effect.

Given that Residual Activation Accounts explain structural priming through gradually decaying residual activation of a combinatorial node, such accounts predict that priming should be strongest when the target immediately follows the prime and should rapidly become weaker with additional sentences or additional time between prime and target. While the results from some studies (e.g., Branigan et al. 1999; Wheeldon and Smith 2003) indeed suggest that priming effects rapidly decay, other studies (e.g., Bock and Griffin 2000; Branigan et al. 2000b; Hartsuiker and Kolk 1998) have instead reported long-lasting priming, with robust priming effects even when prime and target were separated by a considerable number of intervening sentences and/or an extended time period. Based on this finding, the *Implicit Learning Account* explains priming as a form of implicit learning (Chang et al. 2006). The key assumption of the account is that each exposure to a particular sentence structure causes *long-lasting* changes to the respective structural representation. Specifically, the account assumes that during the processing of a sentence, the processor computes an expectation of its syntactic structure. If this expectation is not met (for instance, because the structure of the sentence is relatively rare in the language), syntactic representations are adapted and weight changes are applied. As a result, the system gradually acquires information about syntactic biases (e.g., the fact that the German dative alternation is strongly biased toward the DO) with each exposure through structural priming.

The Implicit Learning Account establishes a connection between sentence processing, structural priming, and language acquisition and is, thus, particularly well-suited to derive predictions for structural priming in children from it. For instance, children who, across their lifetime, have previously encountered a particular structure on only very few occasions (and whose respective structural representation is less stable in the sense that it is based on very few prior observations) should, when being primed by the respective structure, show particularly strong priming effects, due to surprisal. As a result, immediate priming effects should be enhanced in young children and should gradually decrease with higher age due to increased exposure to the structure.

As the account assumes that the effect of a prime should be long-lasting, priming effects should also emerge when the prime and target are separated by intervening linguistic input. Also, as each exposure to a prime sentence causes weight changes, exposure to several primes with the same structure should result in stronger priming, i.e., cumulative priming effects. Just like immediate priming effects, cumulative priming should initially be boosted by surprisal and should gradually decrease with increasing exposure to the structure.

Finally, with regard to the lexical boost effect, the account assumes that, during the formulation of the target, an additional lexical overlap between prime and target serves as a memory cue, which makes it easier to retrieve the prime's structure from memory and repeat it, causing a lexical boost effect (Bock and Griffin 2000; Chang et al. 2006, 2012). For adults, there is at least some experimental support for the claim that the lexical boost is connected to memory: Zhang et al. (2020), in a priming study manipulating the amount of working memory load during the experiment, found weaker priming effects when participants experienced high cognitive load. With regard to the lexical boost in children, the account suggests that lexical boost effects can only emerge when the individual possesses sufficient working-memory capacity. Thus, individuals with limited working memory capacity, such as young children, may show no lexical boost effect. Given that working memory capacity improves with increasing age due to maturation (Naito 1990; Sprondel et al. 2011), the model predicts that the lexical boost effect should gradually emerge with increasing age.

Newer accounts try to integrate residual activation and implicit learning (Ferreira and Bock 2006; Hartsuiker et al. 2008; Reitter et al. 2011) to account for immediate and cumulative priming effects. For instance, Reitter et al. (2011) suggested a hybrid account based on the ACT-R framework. The account is based on the assumption that structural priming effects consist of a short-term and a long-term component, in the sense that immediate priming effects are based partly on residual activation (as assumed by Residual Activation Accounts) and partly on long-term adaptation (as assumed by the Implicit Learning Account). Just like Residual Activation Accounts, this account explains lexical boost effects through associations between structural representations and lexical entries for words, which can occur as part of the respective structure, with spreading activation from the lexical entries causing additional activation of the structural representation. However, unlike in Residual Activation Accounts, such associations are not only assumed for verbs but also for other lexical material, which can occur as part of the respective structure. Thus, lexical boost effects should not only emerge when prime and target share the same verb but also for the repetition of other lexical material. Also, given that the lexical boost is assumed to be based entirely on spreading activation, the account predicts that, unlike the priming effect as such, the lexical boost should rapidly decay.

Unlike the Implicit Learning Account, Reitter's account makes no specific claims about how the assumed processing architecture develops during language acquisition in children. That said, both immediate and cumulative priming effects caused by residual activation should occur as soon as the individual possesses abstract representations for syntactic structures. The fact that priming effects are partly based on long-term adaptation should also lead to surprisal effects in children. Whether or not lexical boost effects emerge in children of a particular age depends on how quickly the assumed associations between structural representations and lexical entries can be established through associative learning.

1.2. The Present Study

Most previous studies investigating structural priming in children have only tested a single age group, and only a few studies have tested two age groups. As a result, fairly little is known about how the above-mentioned effects develop with increasing age. Although structural priming in children as such has been extensively investigated in languages other than English–Spanish (Gámez et al. 2009; Gámez and Shimpi 2015—transitive structures), Chinese (Hsu 2014—SVO-ba alternation with 5-year-olds), Italian (Contemori and Belletti 2023; Manetti and Contemori 2019—relative clauses), Japanese (Arai and Mazuka 2014—transitive structures), Dutch (van Beijsterveldt and van Hell 2009—adjective noun structures), French (Havron et al. 2020—syntactic ambiguities in PP-attachments), Russian (Vasilyeva 2012—transitive structures), and German (Brandt et al. 2017—ambiguous relative clauses; Lehmden 2013—transitive structures), priming effects for the dative alternation in languages other than English have received relatively little attention in child research. To our knowledge, only one such study has been conducted—a study by Wolleb et al. (2018) that investigated cross-linguistic structural priming between Norwegian and English and included a within-Norwegian control experiment with a small sample of Norwegian-speaking children aged 4;5 to 8;5. The results showed similar, significant priming effects within and across languages. Hence, it is not entirely clear to what extent the findings for English on the dative alternation can be generalized across languages.

The key goal of the present study was to gain insight into how syntactic representations in children develop with increasing age. In a German structural priming experiment for the dative alternation, we investigated abstract structural priming, the lexical boost, surprisal effects, and cumulative priming in children from three different age groups (3–4, 5–6, and 7–8) as well as adult controls. The case of the German dative alternation is interesting because, unlike English, German is biased toward the DO structure, even though the PO structure is possible with a wide range of different ditransitive verbs (Adler 2011; Callies and Szczesniak 2008; De Vaere et al. 2018; Drenhaus 2004; Proost 2014, 2015). Our examination of German child and child-directed speech in the CHILDES database revealed that children

between the ages of 1;5 and 7;5 only rarely hear or produce POs. Looking at a biased structure of this kind allows us to test one of the key predictions of the Implicit Learning Account (Bock and Griffin 2000), according to which language input is processed via an error-based learning mechanism (Chang et al. 2000). As a result, less frequent structures (such as the German PO structure) should yield stronger priming due to surprisal.

The task and design of our study are similar to Rowland et al. (2012) and Peter et al. (2015). As part of a bingo game, participants were exposed to a PO or otherwise identical DO prime sentence. Immediately after each prime, they described a video displaying an event that involved an agent, a recipient, and a theme. In addition, we experimentally manipulated whether the verb in the prime sentence and the verb required to describe the action displayed in the target video were the same or not. This design allows us to determine both abstract structural priming and lexical boost effects. We also tested a final exploratory hypothesis (which we did not specify a priori before data collection but which emerged from our preliminary analysis): Is it possible to distinguish between immediate priming (i.e., the influence of the specific prime preceding a target) and cumulative priming (i.e., a gradual increase of PO structures after encountering a number of PO prime sentences while the experiment proceeds)?

Our study addresses four main research questions. First, we assess the general structural bias in German and the strength of the initial representations of POs and DOs across age when not influenced by priming with ditransitive structures (baseline). We hypothesized that the PO structure, the dispreferred option, would be rarely produced by the youngest children but would be increasingly prevalent in older groups. We assumed, however, that the structural bias toward the DO would still be strong across all age groups.

Second, we investigate the developmental trajectory of abstract structural priming effects to gain insight into the stability of syntactic representations in children. If structural priming is indeed a form of implicit learning, the weights of syntactic representations should initially be less stable and, therefore, easier to prime. As a result, abstract structural priming (i.e., priming for prime–target pairs that do not share the same head) should be strongest in younger children, reflecting surprisal, and should subsequently decrease with age.

Third, we examine the lexical boost effect across age groups. Suppose we find abstract priming effects across all age groups but only a developmental trajectory for the lexical boost effect (i.e., lexical boost only in older age groups), that would support Chang et al.'s (2006) assumption that the lexical boost is strongly associated with working memory and emerges across time. Based on Rowland et al.'s (2012) and Peter et al.'s (2015) results, which only observed a numerical trend toward a lexical boost effect in 5- to 6-year-olds, we hypothesize that a significant effect might be present in the 7- to 8-year-olds.

Finally, we investigate cumulative priming during the experiment. According to the Implicit Learning Account, cumulative priming effects should occur as a function of adaptation to the syntactic form with increasing input, irrespective of whether the particular prime immediately preceding a target was a PO or a DO. In our experiment, the dispreferred PO structure is encountered considerably more often than in natural language (given that 50% of all experimental primes are POs). This increased exposure to PO structures should lead to cumulative priming, with a gradual increase of PO targets while the experiment proceeds. Just as for immediate priming, if it is indeed the case that syntactic representations in young children are less stable, 3- to 4-year-olds should show stronger cumulative priming effects than the older groups.

2. Materials and Methods

2.1. Participants

A total of 193 native German-speaking children and adults participated in the study. Specifically, the sample consisted of sixty 3- to 4-year-olds (mean age 3;9, range 3;1–4;11), fifty 5- to 6-year-olds (mean age 5;8, range 5;0–6;10), forty-five 7- to 8-year-olds (mean age 7;9, range 7;0–8;11), and thirty-seven adults (mean age 25;0, range 20–35). No participants were reported as being diagnosed with any cognitive impairment. Fifteen additional children were recruited but excluded from analysis because they did not complete the experimental session.

The children were tested in a separate room in their nurseries and schools in south-western Germany. The adult group consisted of students and employees of the University who participated in payment. They were tested in a quiet laboratory room. After the experiment, each child received a 'thank you' snack box with the logo of the study on it.

2.1.1. Design

The study is based on a 4 (*age group*) × 2 (*prime type*) × 2 (*verb condition*) mixed design, with '*age group*' (3–4 years, 5–6 years, 7–8 years, adults) as a between-subjects variable and '*prime type*' (double object (DO)/prepositional object (PO))[2] and '*verb condition*' (different verb (DV)/same verb (SV) as within-subjects variables. Both '*prime type*' and '*verb condition*' were manipulated within-items. In addition to the experimental session, we included a baseline pretest session in which target pictures were preceded by intransitive (IN) primes to assess participants' initial structural preferences when not primed by either a PO or DO. Each item from the baseline pretest was matched to a particular item with the same target picture in the experiment.

2.1.2. Sentence Stimuli

Our sentence stimuli used four German dative-alternating verbs: *bringen* 'bring', *geben* 'give', *schicken* 'send', and *verkaufen* 'sell'. A prior analysis of CHILDES data showed that these verbs were used frequently in the DO form and occasionally in the PO form in the child and child-directed speech of five German-speaking children aged 1;6–7;5 (MacWhinney 2000; Leo: Behrens 2006; Cosima, Pauline, Sebastian: Lieven and Stoll 2013; Caroline: Von Stutterheim 2014). Further, most of the verbs are documented in the literature on the acquisition of the dative alternation in German (Eisenbeiss et al. 2006; Woods 2015).

As German POs can contain two different prepositions (*zu* and *an*), we conducted a pilot study to check whether the four verbs used in the experimental materials are acceptable when used in combination with a particular preposition. Based on the results from this pilot study, PO materials with the verbs *schicken* and *verkaufen* contained the preposition *an*, while materials with the verbs *bringen* and *geben* contained the preposition *zu*.

As agents and recipients for these verbs, we chose four pairs of cartoon characters: Dora and Boots (from *Dora the Explorer*), Wendy and Bob (from *Bob the Builder*), Jake and Izzy (from *Jake and the Never Land Pirates*), and Mickey and Minnie (from Disney cartoons). As themes, we selected six small animals that could easily be transferred from the agent to the recipient: *der Hase* 'the rabbit', *der Hund* 'the dog', *der Papagei* 'the parrot', *der Schmetterling* 'the butterfly', *der Frosch* 'the frog', and *der Fisch* 'the fish'. We purposefully chose agents and recipients with proper names, as well as themes with masculine gender, in order to avoid complexity with gender and case agreement as has been previously shown for the dative marking (Eisenbeiss et al. 2006; Scherger et al. 2022). Further, all arguments were animate in order to ensure that priming effects would not be affected by animacy contrasts (Bock et al. 1992).

To create the prime sentences (see Appendix A), we first combined the agent–recipient pairs and themes to create 16 character groupings (e.g., *Dora-Boots-Hasen*), with each agent–recipient represented four times, and each theme represented either three or four times. We also created 16 target combinations, respectively. Each verb appeared four times across the 16 prime–target pairs (items), once with each agent–recipient pair. Each target (e.g., *Micky-geben-Minnie-Papagei*) was paired with a prime sentence from a different character set containing four versions: a DO and PO structure in the different verb (DV) condition (e.g., *Dora bringt Boots den Hasen/Dora bringt den Hasen zu Boots*) and a DO and PO structure in the same verb (SV) condition (e.g., *Dora gibt Boots den Hasen/Dora gibt den Hasen an Boots*). This ensured no lexical overlap between primes and targets other than the verb in the SV condition. Correspondingly, each verb appeared once in each prime condition (PO-DV, DO-DV, PO-SV, DO-SV). Thus, there were 64 prime sentences in total. The items were equally distributed across four presentation lists, with each participant tested on one presentation list only. As a result, each participant encountered 16 experimental prime–target pairs (i.e., four items from each of the four conditions) during testing. Each verb was presented eight times per list, four times in the prime and four times in the target.

Immediately before the actual experiment, participants went through a baseline pretest consisting of prime–target pairs with intransitive primes (henceforth IN) in order to assess participants' initial PO/DO production preferences when not primed with ditransitives. The intransitive prime sentences used in this pretest described non-causal actions (e.g., *Dora schwimmt* 'Dora is swimming'). In the baseline pretest, each child encountered four items with intransitive primes. To allow for a direct comparison between the results from the baseline pretest and those from the PO and DO prime conditions in the DV condition in the actual experiment, each target sentence used in the pretest was matched to a particular target sentence in the experimental session. As the experimental session contained more targets than the pretest, two matched versions of the pretest were created, with each of the 2×4 pretest items matched to a particular item in the experimental session.

2.1.3. Visual Stimuli

We designed a total of 82 animated video clips using *Anime Studio Pro 10* to depict each of the sentence stimuli. This included 36 clips depicting transfer actions (*give, bring, send, sell*), which were used as prime and target stimuli for the experimental items, and 46 clips depicted non-causal intransitive actions. We controlled for directional effects by displaying the action either from right to left (R > L) or from left to right (L > R) and counterbalanced the order across lists. The action in the corresponding prime and target clip always traveled in opposite directions. The video clips were presented in E-Prime 2.0 on a laptop computer. The experiment took place as a modified Bingo game[3] in which picture cards (still images of corresponding video clips) were collected to fill up a Bingo grid with blank spaces.

2.2. Procedure

Prior to playing the game, the experimenter introduced all of the characters appearing during the game on individual cards to ensure that children would not fail on descriptions due to character recognition difficulty. The main experimenter and the child sat next to each other in front of a laptop screen and described videos in turns. A second experimenter held up a puppy hand puppet named Mobi, who had a set of bingo cards depicting some of the video actions. The main experimenter modeled the prime sentence while the video actions unfolded (e.g., *Dora gibt den Hasen an Boots* 'Dora gives the rabbit to Boots'). The participant was then asked to repeat the sentence, with the explanation that Mobi could only comprehend child speech. The main experimenter then modeled the agent and verb of the target sentence corresponding to the participant's video clip (e.g., *Jake schickt* . . . 'Jake sends. . .'). The participant repeated the agent and verb, and then completed the sentence on their own. This stem completion technique ensured that participants would use the target verb, even if the action could be described with a different verb (Pickering and Branigan 1998). If the child produced an incomplete target structure, the main experimenter prompted them using phrases designed not to bias any particular structural option (e.g., *Please name all characters/objects on the screen; Please describe the whole action in one sentence; Can you include him/her in the sentence*?). After every time either the participant or the main experimenter produced a sentence, Mobi handed over a card to fill the bingo grid of each player if the sentence produced matched one of his cards. For the 7- to 8-year-olds, there was no second experimenter; instead, the experimenter or child put a stamp on their Bingo grid when a happy face was displayed on the laptop screen. The system of filling up the grids was the same across all groups, with the participant always being the winner.

In total, the test session consisted of three Bingo games: Game 1 (practice), Game 2 (baseline pretest; 4 intransitive primes), and Game 3 (priming experiment; 8 PO and 8 DO primes). For the groups of children aged 3–4 years and 5–6 years, the experiment was split into two test sessions, with Games 1 and 2 taking place in the first and Game 3 in the second session. The second test session took place 1–4 weeks after the first. Children aged 7–8 years and adults completed all three games in a single session.

Coding of Priming Data

The audiotaped target responses were transcribed and coded as either 'PO', 'DO', or 'other' by two coders. The agreement rate between coders was 98% for both transcription and coding.

In total, the data set consisted of 3860 target utterances. These were coded as 'PO' when the verb was followed by an object NP specifying the theme and then by a prepositional object specifying the recipient (NP_PP; e.g., *den Hasen an Bob* 'the rabbit to Bob'). Sentences in which the two objects were scrambled (PP_NP; e.g., *an Bob den Hasen* 'to Bob the rabbit'; 3.0% of all utterances) and sentences in which participants used a different preposition with the recipient (7.4% of all utterances) were also coded as 'PO'. Targets were coded as 'DO' when the verb was followed by an object NP specifying the recipient and then by a second object NP specifying the theme without any prepositions (NP_NP; e.g., *Bob den Hasen* 'Bob the rabbit'). Targets in which the order of the two objects was scrambled (NP_NP; e.g., *den Hasen Bob* 'the rabbit Bob'; 7.2% of all utterances) also counted as 'DO' targets.

Note that target responses were coded even if the participant used a different name for a character (1.9% of all utterances), used incorrect case marking on the theme (2.3% of all utterances), omitted the determiner (1.7% of all utterances), failed to produce the modeled target subject and/or verb themselves (11.7% of all utterances), or used a different verb than modeled (1.5% of all utterances). Responses were also coded if the direct or indirect object was realized by a pronoun or demonstrative, given that the relevant ditransitive structure was still evident (0.3% of all utterances). If the response for a target consisted of more than one sentence (e.g., a monotransitive structure followed by a ditransitive structure or a PO followed by DO), only the first structure resembling a ditransitive was coded. Any target responses not conforming to the above designation as 'PO' or 'DO' (i.e., grammatically incorrect responses, incomplete responses, and grammatically correct responses that were neither a PO nor a DO, such as monotransitive responses) were coded as 'other' (6.4%) and were excluded from the analysis.

As is typical in studies with children, the younger child groups (age 3–6) often omitted sentence constituents or used an alternative structure (see Bencini and Valian 2008 for similar observations). Thus, we followed Peter et al.'s (2015) approach of categorizing the data according to three coding schemes: *strict*, *intermediate*, and *lax*. The criteria for the strict coding included the following: (1) no more than one prompt to repeat the prime sentence, (2) only the prepositions *an* and *zu* in prime repetitions and target responses, and (3) only the correct verb. The criteria for the intermediate coding included the following: (1) any number of prompts to repeat the prime sentence, (2) any preposition for prime repetition and target responses except von 'of/from' since it takes the structure of a PO (*Wendy bringt den Frosch von Bob* 'Wendy brings the frog of/from Bob') but does not imply the meaning of transfer, and (3) any verb in the DV condition as long as it was one of the experimental verbs and the prime and target verbs were different. The criteria for the lax coding included the same criteria as for intermediate coding except that all prepositions were allowed and that ditransitive verbs not included in the design were accepted in the target. As the analyses on all three coding schemes revealed very similar patterns of results, only the results for the strict coding scheme are reported below.

3. Results

3.1. General Bias for the German DO Structure

The results from the baseline pretest showed a bias in favor of the DO structure for all four age groups, with an average use of 78% DOs vs. 22% POs across all participants. This bias was strongest in the 3- to 4-year-olds (90% DOs produced in the baseline relative to 10% POs) and gradually decreased in the older child groups (75% DOs vs. 25% POs in the 5- to 6-year-olds; 68% DOs vs. 32% POs in the 7- to 8-year-olds). The adult group also showed a bias toward the DO structure (79% DOs vs. 21% POs).

3.2. Immediate Priming and the Lexical Boost Effect

We analyzed the data using logit mixed effects models, which are well suited to analyze binary dependent measures like structural choice (Baayen et al. 2008; Barr et al.

2013; Jaeger 2008). Analyses were carried out in "R version 4.2.1 (2022-06-23)" (R Core Team 2021) using *glmer* in the *lme* package (e.g., lme4 version 1.1-30). All models included by-subject and by-item (where "item" is each prime–target pair of all conditional combinations) random intercepts and random slopes, known as the *maximal model* following Barr et al. (2013). If a model did not reach convergence, we applied the optimizer *bobyqa* (bound optimization by quadratic approximation) taken from the *nloptr* package, which helped to achieve a stable maximal model for all our analyses.[4]

Figure 1 shows the mean proportion of PO responses (relative to the sum of all PO and DO responses, excluding 'other' responses) by condition and age group. Across all age groups, we observed numerical trends toward structural priming, with a higher proportion of PO targets following PO primes than following DO primes in both the SV and DV conditions.

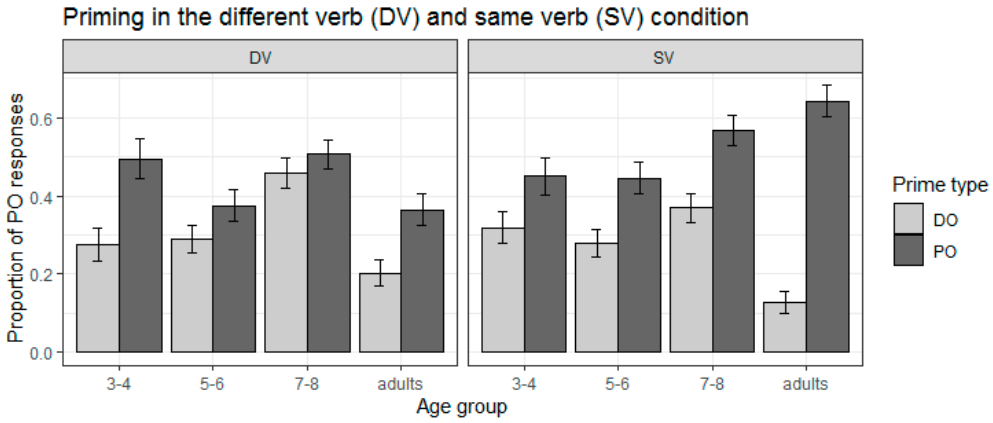

Figure 1. Mean proportion of PO responses after double object (DO) and prepositional object (PO) primes in the different verb (DV) and same verb (SV) conditions (Error bars are based on SE).

We fitted a logit mixed-effects model to the data. The model contained 'prime type' (DO vs. PO), 'verb condition' (SV vs. DV), 'age group', and their interactions as fixed effects. 'Prime type' and 'verb condition' were centered prior to analysis. For 'age group', a sum contrast was applied[5]. The results from the model are shown in Table 1 below.

Table 1. Results from the logistic mixed-effects model on the PO productions as a function of prime type, verb condition, and age group.

Fixed Effect	β	SE	z	p	
(intercept)	−0.89	0.29	−3.10	**<0.01**	**
prime type (DO vs. PO)	1.20	0.18	6.55	**<0.001**	**
verb condition (DV vs. SV)	0.31	0.18	1.67	0.10	
3- to 4-year-olds (vs. grand mean)	−0.12	0.26	−0.45	0.66	
5- to 6-year-olds (vs. grand mean)	−0.25	0.26	−0.96	0.34	
7- to 8-year-olds (vs. grand mean)	0.66	0.27	2.42	**0.02**	*
prime type * verb condition	0.76	0.30	2.50	**0.01**	*
prime type * 3- to 4-year-olds	−0.29	0.28	−1.05	0.29	
prime type * 5- to 6-year-olds	−0.47	0.21	−2.29	**0.02**	*
prime type * 7- to 8-year-olds	−0.34	0.26	−1.33	0.18	
3- to 4-year-olds * verb condition	−0.04	0.29	−0.15	0.88	
5- to 6-year-olds * verb condition	−0.01	0.24	−0.02	0.98	
7- to 8-year-olds * verb condition	−0.35	0.30	−1.18	0.24	
prime type * 3- to 4-year-olds * verb condition	−1.22	0.48	−2.55	**0.01**	*
prime type * 5- to 6-year-olds * verb condition	−0.31	0.49	−0.63	0.53	
prime type * 7- to 8-year-olds * verb condition	0.18	0.43	0.41	0.68	

Based on 2388 observations. Strict coding; LogLik = −1195.6. Random effects include by-subject and by-item intercepts; by-subject random slopes for 'prime type' and 'verb condition'; and by-item random slopes for 'prime type', 'verb condition', and 'age group'. * = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

The model revealed a main effect of 'prime type', indicating a priming effect across all age groups irrespective of 'verb condition' and 'age group'. The model also showed a significant main effect for the group of 7- to 8-year-olds, indicating that, irrespective of the prime, this age group produced significantly more POs than the sample overall. We also found a significant two-way interaction between 'prime type' and 'verb condition', with significantly stronger priming in the SV condition than in the DV condition, i.e., a lexical boost effect, and a significant two-way interaction between 'prime type' and the age group of 5- to 6-year-olds, with weaker priming for this age group than for the sample as a whole. Finally, the results revealed a significant three-way interaction between 'prime type', 'verb condition', and the age group of 3- to 4-year-olds, suggesting that the group of 3- to 4-year-olds differed from the other groups with regard to the lexical boost effect.

Priming Effects and the Lexical Boost within Each Age Group

To explore the observed interactions in the above omnibus model in more detail, we fitted additional, separate logit mixed-effects models to the data from each age group. Each model contained 'prime type (DO vs. PO)', 'verb condition (SV vs. DV)', and the interaction between the two as centered fixed predictors. The results from these analyses are shown in Table 2. For all four age groups, these model analyses revealed significant main effects of 'prime type', with more PO targets following PO primes than following DO primes. As indicated by the β coefficients for the main effect of 'prime type' in each group, priming was numerically more robust in the adult group than in the three child groups. With respect to lexical boost effects, only the adults showed a significant two-way interaction between 'prime type' and 'verb condition'. While the 5- to 6-year-olds and 7- to 8-year-olds also showed numerical trends toward a lexical boost, this trend was only marginally significant for the 7- to 8-year-olds and non-significant for the 5- to 6-year-olds.

Table 2. Priming effects and lexical boost by age group.

	β	SE	z	p	
age group					
3–4					
(intercept)	−1.04	0.36	−2.94	**<0.01**	**
prime type	0.88	0.29	3.08	**0.002**	**
verb condition	0.12	0.30	0.40	0.69	
prime type * verb condition	−0.22	0.58	−0.35	0.73	
5–6					
(intercept)	−1.16	0.42	−2.77	**<0.01**	**
prime type	0.80	0.24	3.39	**<0.001**	***
verb condition	0.24	0.26	0.92	0.36	
prime type * verb condition	0.73	0.55	1.32	0.18	
7–8					
(intercept)	−0.21	0.45	−0.46	0.65	
prime type	0.80	0.31	2.62	**<0.01**	**
verb condition	−0.01	0.41	−0.04	0.97	
prime type * verb condition	0.79	0.41	2.00	0.051	
adults					
(intercept)	−1.01	0.26	−3.84	**<0.001**	***
prime type	2.22	0.34	6.50	**<0.001**	***
verb condition	0.46	0.26	1.80	0.071	
prime type * verb condition	2.46	0.64	3.83	**<0.001**	***

* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

To obtain effect sizes for the priming effects in each age group, we conducted additional model analyses with only 'prime type' as a fixed effect, separately for the DV and SV conditions. Table 3 reports the β coefficients for the priming effects in the SV and DV conditions for each age group, which contain information about the size of the priming effect.

Table 3. Effects sizes for priming effects in the different verb (DV) versus same verb (SV) conditions by age group.

Age Group	Different Verb (DV)			Same Verb (SV)		
	β	SE	*p*	*β*	SE	*p*
3–4	1.48	0.42	0.000 ***	0.79	0.37	0.01 *
5–6	0.39	0.34	0.25	1.23	0.37	0.000 ***
7–8	0.43	0.32	0.18	1.17	0.35	0.000 ***
adults	0.93	0.41	0.02 *	3.26	0.46	0.000 ***

* = $p < 0.05$, ** = $p < 0.01$, *** = $p < 0.001$.

Both the significant three-way interaction in the omnibus model and the results from the separate analyses for each age group suggest group differences with regard to the lexical boost effect. Figure 2 shows the size of the lexical boost (i.e., the difference between the amount of priming in the SV versus the DV condition) and its distribution by age group.

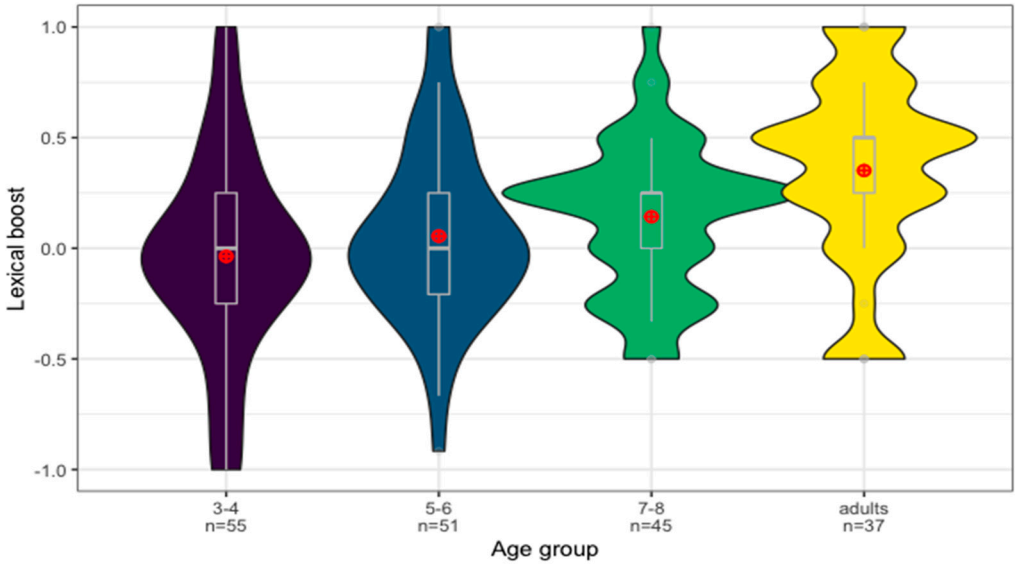

Figure 2. Lexical boost effects (i.e., the difference between the amount of priming in the SV versus the DV condition) by age group. Mean lexical boost effects are represented by red dots (i.e., the difference between the amount of priming in the SV versus the DV condition).

While the other three age groups showed numerical trends toward a lexical boost effect, with stronger priming in the SV than in the DV condition, the 3- to 4-year-olds instead showed no signs of a lexical boost effect but instead stronger abstract priming in the DV condition than in the SV condition. We will further comment on this in the discussion.

To explore the developmental trajectory for the lexical boost effect in more detail, we also ran a supplementary model analysis in which 'age in months' was included as a centered continuous predictor. We did not include the adult group in this analysis because age differences within the adult group do not contain the same developmental information as in children. 'Prime type' and 'verb condition' were again sum-coded. In addition to the main effect of prime type (β = 0.82 (SE = 0.20), z = 4.06, $p < 0.001$), the results also showed a significant three-way interaction between 'prime type', 'verb condition', and 'age in months' (β = 0.03 (SE = 0.01), z = 2.26, $p = 0.02$). This confirms that the age groups differ with regard to the lexical boost.

3.3. Priming Relative to the Baseline Pretest and Cumulative Priming

In an additional analysis, we compared the results from the PO and DO prime conditions with those from the intransitive baseline pretest. This comparison is potentially informative with regard to surprisal effects: If it is indeed the case that structures that are only rarely encountered (such as the German PO structure) cause stronger priming due to surprisal, we should observe stronger priming for PO primes than for DO primes relative to the intransitive baseline. This effect should be stronger for younger children due to less prior exposure to PO structures. The items used in the baseline pretest did not contain the same verb in prime and target and were, thus, not comparable with the SV condition. To allow for a direct comparison between the results from the baseline pretest and the experiment, each item from the pretest was matched to a particular experimental item from the DV condition. This ensured that each baseline trial could be compared to a corresponding PO and DO trial with the same target stimulus. Figure 3 shows the proportion of PO target responses for IN primes from the baseline pretest and their corresponding PO and DO counterparts from the experimental session, separately for each age group. (Note that, due to the fact that the DV condition in the experiment contained twice as many items as the pretest, the PO and DO bars in Table 3 are not based on all PO and DO items but only on those matched to a particular item in the pretest).

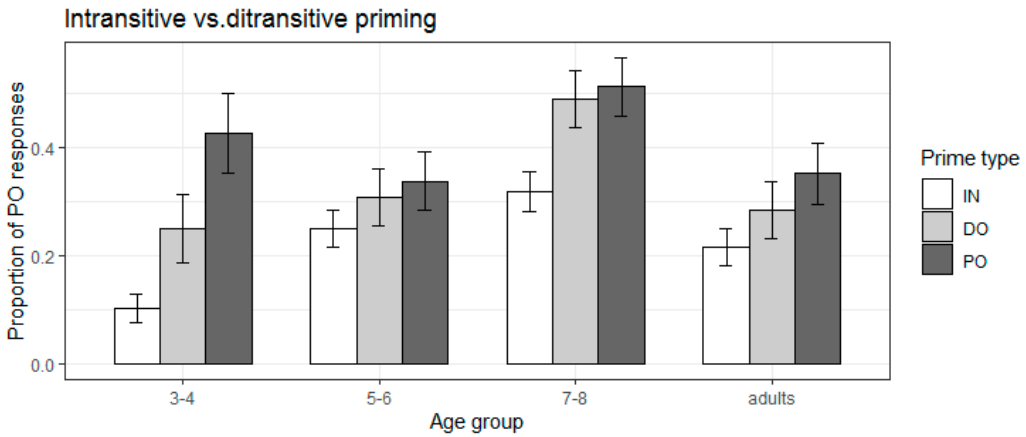

Figure 3. Mean proportion of responses that are POs after intransitive (IN) primes (baseline) compared to double object (DO) and prepositional object (PO) primes in the different verb conditions (error bars represent standard errors).

We fitted a logit mixed effects model with two contrasts for 'prime type' ('DO vs. IN' and 'PO vs. IN'), 'age group', and their interactions as fixed effects. We used treatment coding for 'prime type' with IN primes serving as the reference level and applied a sum contrast for 'age group' as in the previous model. The model revealed a main effect of PO prime vs. IN prime ($\beta = 1.58$ (SE = 0.42), $z = 3.79$, $p < 0.001$), indicating that participants were significantly more likely to produce PO structures after a PO prime than after an IN prime. Further, there was also a main effect of DO prime vs. IN prime ($\beta = 1.12$ (SE = 0.39), $z = 2.89$, $p < 0.001$), indicating more PO targets (and, therefore, fewer DO targets) after a DO prime than after an IN prime for all participant groups. As indicated by the main effect of the 3- to 4-year-olds ($\beta = -1.59$ (SE = 0.54), $z = -2.95$, $p < 0.001$), the youngest child group generally produced more POs in the experimental session than the older groups. The results also showed a two-way interaction of PO vs. IN prime and the group of 3- to 4-year-olds ($\beta = 1.54$ (SE = 0.65), $z = 2.36$, $p < 0.05$), suggesting that the priming effect for PO primes relative to the baseline was stronger in 3- to 4-year-olds than in the other groups.

Note, however, that for all participant groups, the intransitive baseline pretest showed a highly unexpected result: We expected PO primes to raise the PO/DO ratio relative to the baseline (i.e., with relatively more PO and fewer DO targets produced), and DO primes to lower it, with the ratio for the baseline pretest situated between the two prime conditions.

However, all participant groups produced more DO target sentences following IN primes than following DO primes. As a result, it was obviously not possible to utilize the baseline pretest as a control condition to determine priming effects separately for POs and DOs, as originally intended. However, the fact that this observation was consistent across all four participant groups suggests that the unexpectedly low PO/DO ratio in the baseline pretest was not a fluke and, therefore, demands an explanation. One possibility is that during the experimental session, structural choices made by the participants were not only affected by immediate priming (i.e., the influence of the prime sentence immediately preceding the respective target) but also by cumulative priming (i.e., the influence of the overall ratio of PO vs. DO sentences encountered during the test session). While PO sentences are only rarely encountered in natural language, 50% of all experimental prime sentences encountered during the experimental session were PO primes. This high proportion of PO sentences during the experimental session might have increased participants' tendency to produce PO targets, in addition to the influence of the preceding prime. We investigated this possibility in an additional post-hoc analysis of the data from the experimental session, in which we included 'trial number' as an additional predictor in the model. If the results are affected by cumulative priming, this should lead to a main effect of 'trial number', with more POs produced toward the end of the experiment. As illustrated in Figure 4, the proportion of PO targets indeed increased with increasing trial numbers in all four age groups, irrespective of whether the immediately preceding prime was a PO or DO. This effect decreased with growing age.

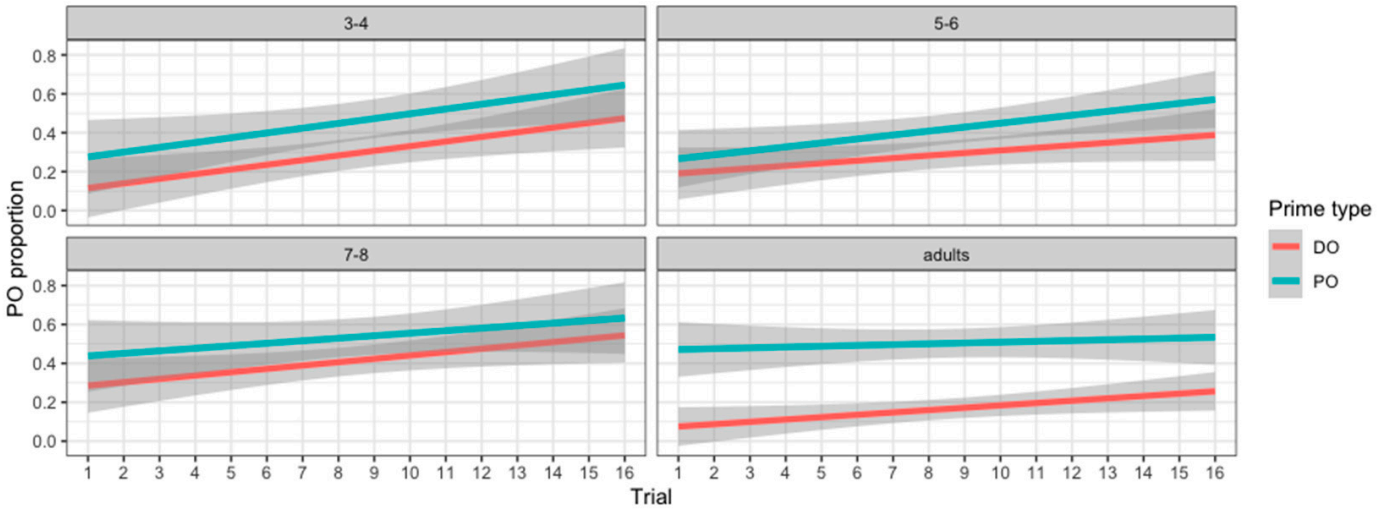

Figure 4. Cumulative priming effects as a function of trial number (16 trials) and prime type (PO/DO) in four age groups (shadowed area represents SE).

To test these numerical trends for statistical significance, we conducted an additional model analysis which included 'prime type', 'age group', 'trial number', and their interactions as fixed effects. In addition to the significant effects reported in the main model above, the analysis revealed a significant main effect of 'trial number' ($\beta = 0.09$ (SE = 0.02), $z = 5.54$, $p < 0.001$), with a linear increase of PO responses during the experiment, as well as a two-way interaction between 'trial number' and the 3- to 4-year-olds ($\beta = 0.06$ (SE = 0.03), $z = 2.43$, $p < 0.02$), indicating that the effect of 'trial number' was significantly stronger in 3- to 4-year-olds than in the sample as a whole. In addition, just as in the main analysis, the model showed a main effect of 'prime type' ($\beta = 1.16$ (SE = 0.18), $z = 6.22$, $p < 0.001$), with more POs produced following PO primes than following DO primes irrespective of 'age group' and 'trial number'. This suggests that structural choices for target sentences were influenced by both immediate and cumulative priming.

4. Discussion

The key research questions investigated in the present study were designed to gain insight into how syntactic representations in children develop with increasing age: (1) what kind of structural representations German-speaking children of various age ranges possess at baseline; (2) whether structural representations in children are less stable than in older individuals and, therefore, easier to prime (surprisal effects) by comparing priming effects sizes across age; (3) whether children already show a lexical boost effect from the start or whether this effect only gradually emerges with age; and (4) whether structural representations in children are subject to implicit learning by exploring cumulative priming effects. In the following, we discuss our experimental results with reference to these four questions.

4.1. Initial Structural Representations in Children

In the baseline data in the present study, we found the hypothesized pattern of structural bias, with an average use of 78% DOs and 22% POs across the four age groups (in line with Kholodova and Allen 2023). Our prediction that the youngest children would show the strongest DO bias (90%), which would decrease with increasing age, was confirmed both descriptively and by the model. This suggests initially weaker structural representations for the PO structure, which become somewhat stronger across age. Note, however, that the adult group actually showed a stronger bias toward the DO structure than the 7- to 8-year-olds.

4.2. Abstract Immediate Structural Priming Effects

During the priming session, all age groups in our study showed immediate structural priming effects, suggesting that children as young as 3–4 years of age already possess abstract representations for syntactic structures. In this respect, our results are consistent with a considerable number of previous studies that have also shown significant structural priming effects for this age group.

As shown by both the interactions in the omnibus model and the effect sizes shown in Table 3, abstract structural priming (i.e., the priming effect in the DV condition) in the 3- to 4-year-olds was stronger than in the older groups. This finding is consistent with the results from several previous studies, which observed at least a numerical trend for stronger priming in young children than in adults (Messenger et al. 2011; Peter et al. 2015; Rowland et al. 2012; Thothathiri and Snedeker 2008b; Wolleb et al. 2018). A possible explanation for enhanced priming effects in young children is offered by the Implicit Learning Account (Chang et al. 2000, 2006), which predicts that, due to surprisal, less prior exposure to the respective syntactic structure should lead to stronger priming effects. With regard to this issue, note that stronger priming effects have also been reported for other speaker groups who have experienced less prior exposure to a particular structure, such as L2 speakers (Flett 2006). In our case, 3- to 4-year-olds have come across ditransitive structures substantially less often than older speakers, which may have caused surprisal. For the German dative alternation, such surprisal effects may be additionally boosted by the fact that German is heavily biased in favor of the DO structure. Thus, in addition to little prior exposure to ditransitive structures in general, prior exposure to PO structures was particularly low for 3- to 4-year-olds, potentially leading to particularly strong priming effects enhanced by surprisal. In sum, our findings are consistent with the claim that syntactic representations in children are less stable and, therefore, more susceptible to the influence of a prime.

The Lexical Boost Effect and Its Development across Age

While the 3- to 4-year-olds in our study showed structural priming, no lexical boost effect emerged for this age group. Instead, the significant interactions in both the omnibus model and in the additional analysis, which included age as a continuous predictor, suggest that, unlike the priming effect, the lexical boost gradually develops with increasing age. This finding is consistent with Kumarage et al.'s (2022) longitudinal study on active/passive

priming in English, where the lexical boost also showed a developmental trajectory, and with the results from a number of previous studies in which the lexical boost did not occur in children but only in adult control groups (Foltz et al. 2015; Peter et al. 2015; Rowland et al. 2012; Thothathiri and Snedeker 2008a).

In studies investigating structural priming in children, a lack of a lexical boost effect has typically been attributed to limited working memory capacity in children. Indeed, if a verb that is encountered during the processing of the prime cannot be kept in working memory for long enough, the processor may not be aware that the prime and target share the same verb. As a result, lexical boost effects should only emerge when working memory capacity is sufficiently developed through maturation, leading to the developmental trajectory observed in our study. The developmental trajectory for the lexical boost observed in our study is consistent with this account. Note, however, that the slope of this developmental trajectory differs considerably between studies. For instance, in Kumarage et al.'s (2022) longitudinal study on English, lexical boost effects emerged at a substantially earlier age than in our study, with a robust lexical boost at 4;6 years of age. Similar results were also reported by Rowland et al. (2012), with evidence for a marginal lexical boost in 5- to 6-year-olds. Our results, in contrast, showed a considerably slower developmental trajectory, with no lexical boost at all in 5- to 6-year-olds, and even 7- to 8-year-olds showing a substantially weaker lexical boost than adults. Also, recall again that at least some previous structural priming studies that have investigated the lexical boost in only a single age group (Branigan and McLean 2016; Branigan et al. 2004; Gerard and Keller 2010; Messenger and Hardy 2017; Morris and Scheepers 2015; Savage et al. 2003) report significant lexical boost effects in children at age 5–6 or younger. This suggests that working memory capacity at this age is, in principle, sufficient for lexical boost effects to emerge and that whether and at which age the effect emerges also depends on other properties of the specific language and structural alternation investigated. Finally, priming studies on children aside, a working-memory-based explanation for the lexical boost effect is potentially inconsistent with recent findings on the lexical boost in adult speakers. In particular, if it is the case that (as claimed by the Implicit Learning Account) the lexical boost emerges because a content word that occurs in both the prime and target serves as a memory cue for the prime, lexical boost effects should occur irrespective of the syntactic function of the shared content word. Indeed, Scheepers et al. (2017) found lexical-boost effects not only for prime–target pairs that shared the head verb but also for shared non-head constituents. In several recent studies investigating the lexical boost in adults, however, robust lexical boost effects only emerged when the head verb was repeated in the target, with either no or considerably reduced effects for the repetition of other lexical material, such as the subject or one of the objects (e.g., Carminati et al. 2019; van Gompel et al. 2023). If correct, these findings point toward residual activation as the locus of lexical boost effects, at least in adults. In sum, given that only very few studies have investigated the developmental trajectory of the lexical boost effect by comparing groups of children of different ages, it is too early to draw any strong conclusions about this issue. Future research on this issue should investigate the possible role of task demands and properties of the specific structural alternation investigated.

4.3. Surprisal Effects and Implicit Learning

In our baseline pretest, we clearly found a relatively strong DO bias in German that was most strongly reflected in the youngest children. When primed with ditransitives, all age groups showed an increase in PO production after a PO prime compared to an IN prime, but this effect was twice as high in the 3- to 4-year-olds, suggesting strong surprisal effects. In fact, we find that the youngest children are most susceptible to priming and thus most likely to change their structural representations (Chang et al. 2006; Jaeger and Snider 2008). However, for all four age groups, the results from the baseline pretest with intransitive prime sentences revealed an unusual and unexpected pattern, with participants producing an even higher proportion of DO targets in the baseline pretest than after being primed by a DO in the actual experiment. A possible explanation for this

unusual observation is that structural choices for target sentences during the experimental session may be affected not only by immediate priming (i.e., by the structure of the prime sentence encountered immediately before the respective target) but also by cumulative priming (i.e., the overall proportion of PO vs. DO sentences encountered during the entire experimental session). Indeed, the results from our post-hoc analysis, which included the trial number as an additional predictor, showed a cumulative priming effect in addition to immediate priming: Irrespective of whether the preceding prime was a PO or DO, the probability of producing a PO target increased while the experimental session proceeded. As predicted by the Implicit Learning Account, these cumulative priming effects, just as the immediate priming effects discussed above, turned out to be strongest in 3- to 4-year-olds and declined with increasing age. This finding constitutes another indication that syntactic representations in young children may be less stable (in the sense that children have only experienced a small number of previous encounters with the respective structure) and, therefore, more susceptible to cumulative priming. Older children, in contrast, have already encountered the respective structure considerably more often, leading to relatively more stable representations and, thus, weaker priming effects.

Cumulative effects in children have been mainly found in blocked designs (Gámez and Shimpi 2015; Huttenlocher et al. 2004; Kidd 2012a, 2012b; Savage et al. 2006; Serratrice et al. 2015), which makes it difficult to disentangle immediate and cumulative priming. A few studies used alternating structures in their experiments by comparing earlier and later sessions (Branigan and Messenger 2016; Messenger 2021). Both found cumulative priming effects, but there was no indication of greater effects in children. In the few studies that investigated cumulative effects on a trial by trial basis, the results for cumulative priming were not entirely clear. Messenger et al. (2011) did not find any cumulative effects in either children or adults, while in Branigan and McLean (2016), cumulative effects in children only reached significance in the analysis for lenient coding. One possible reason why the effect came out so clearly in the present study may be that in German, the dative alternation is strongly biased toward the DO. As a result, cumulative priming for the generally rare PO structure during the experimental session may have been substantially boosted by surprisal.

5. Conclusions

In summation, the following key findings from the present study strike us as particularly relevant. First, German-speaking children at the age of 3–4 years showed enhanced immediate and cumulative priming effects for prepositional object structures relative to older children and adults due to surprisal, suggesting that abstract syntactic representations in this age group are less stable and stabilize with increasing exposure.

Second, while 3- to 4-year-olds already showed robust abstract priming, this effect was not enhanced when prime and target shared the same verb. Instead, the lexical boost only gradually emerged with increasing age, starting no earlier than 7- to 8 years of age. While our results for the presence of abstract structural representations across all child groups are largely consistent with previous child studies, the results for the lexical boost effect and its developmental trajectory differ from the results obtained by at least some previous child research on English, in which lexical boost effects were present from early on. Future studies should determine to what extent our findings generalize across different languages, age ranges, and structural alternations.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics committee of the University of Kaiserslautern-Landau (protocol code 5/2014, 8 May 2014).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study, as well as their parents.

Data Availability Statement: Data and all analyses (R script) are available on OSF: https://osf.io/gknb4/?view_only=73611a184ba146c2b33a0a9d9f3806d5 (accessed on 30 October 2023).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Experimental Items

Prime sentences before the slash are presented in the DO structure; those after the slash are in the PO structure. Each character pair occurred four times as a prime and was combined once with each verb (*geben* 'give'; *bringen* 'bring'; *verkaufen* 'sell' and *schicken* 'send'). Target stems used the same combination of agent, verb, recipient, and theme as prime sentences (e.g., *Micky gibt Minnie den Papagei* ('Micky is giving Minnie the parrot') or *Micky gibt den Papagei an Minnie* ('Micky is giving the parrot to Minnie') for the target set A. Target set B was designed to be the same except for the theme *Frosch* (e.g., 'frog')). The eight intransitive primes used in the baseline contained each agent of a character pair twice combined with eight intransitive verbs (presented under prime sentences in italics).

German	**English**
Dora gibt Boots den (Hasen/Frosch)/den (Hasen/Frosch) an Boots	Dora is giving Boots the (rabbit/frog)/the (rabbit/frog) to Boots
Dora schwimmt.	*Dora is swimming.*
Dora bringt Boots den (Hasen/Frosch)/den (Hasen/Frosch) zu Boots	Dora is bringing Boots the (rabbit/frog)/the (rabbit/frog) to Boots
Dora verkauft Boots den (Papagei/Hund)/den (den Papagei/Hund) an Boots	Dora is selling Boots the (parrot/dog)/the (parrot/dog) to Boots
Dora springt.	*Dora is jumping.*
Dora schickt Boots den (Papagei/Hund)/den (den Papagei/Hund) zu Boots	Dora is sending Boots the (parrot/dog)/the (parrot/dog) to Boots
Jake gibt Izzy den (Schmetterling/Papagei)/den (Schmetterling/Papagei) an Izzy	Jake is giving Izzy the (butterfly/parrot)/the (butterfly/parrot) to Izzy
Jake bringt Izzy den (Schmetterling/Papagei)/den (Schmetterling/Papagei) zu Izzy	Jake is bringing Izzy the (butterfly/parrot)/the (butterfly/parrot) to Izzy
Jake tanzt.	*Jake is dancing.*
Jake verkauft Izzy den (Fisch/Frosch)/den (Fisch/Frosch) an Izzy	Jake is selling Izzy the (fish/frog)/the (fish/frog) to Izzy
Jake fliegt.	*Jake is flying.*

Jake schickt Izzy den (Fisch/Frosch)/den (Fisch/Frosch) zu Izzy	Jake is sending Izzy the (fish/frog)/the (fish/frog) to Izzy
Wendy gibt Bob den (Hund/Hasen)/den (Hund/Hasen) an Bob	Wendy is giving Bob the (dog/rabbit)/the (dog/rabbit) to Bob
Wendy saugt.	*Wendy is (vacuum) cleaning.*
Wendy bringt Bob den (Schmetterling/Hasen)/den (Schmetterling/Hasen) zu Bob	Wendy is bringing Bob the (butterfly/rabbit)/the (butterfly/rabbit) to Bob
Wendy verkauft Bob den (Hund/Hasen)/den (Hund/Hasen) an Bob	Wendy is selling Bob the (dog/rabbit)/the (dog/rabbit) to Bob
Wendy schickt Bob den (Schmetterling/Hasen)/den (Schmetterling/Hasen) zu Bob	Wendy is sending Bob the (butterfly/rabbit)/the (butterfly/rabbit) to Bob
Wendy schaukelt.	*Wendy is swinging.*
Micky gibt Minnie den (Fisch/Schmetterling)/den (Fisch/Schmetterling) an Minnie	Micky is giving Minnie the (fish/butterfly)/the (fish/butterfly) to Minnie
Micky läuft.	*Micky is walking.*
Micky bringt Minnie den (Fisch/Hund)/den (Fisch/Hund) zu Minnie	Micky is bringing Minnie the (fish/dog)/the (fish/dog) to Minnie
Micky verkauft Minnie den (Fisch/Schmetterling)/den (Fisch/Schmetterling) an Minnie	Micky is selling Minnie the (fish/butterfly)/the (fish/butterfly) to Minnie
Micky schickt Minnie den (Fisch/Hund)/den (Fisch/Hund) zu Minnie	Micky is sending Minnie the (fish/dog)/the (fish/dog) to Minnie
Micky winkt.	*Micky is waving.*

Notes

1 Initially, we did not intend to investigate cumulative priming effects. However, an unusual effect in the results led us to running an analysis which pointed towards cumulative effects. Because this analysis may considerably contribute to child priming research, we decided to include cumulative effects as an additional research question in this paper but because this hypothesis was not determined a priori it should be considered exploratory.

2 In contrast to our design, Rowland et al. (2012) included 'Verb Condition' as a between-subjects variable, in order to reduce the number of items presented to each child. We opted to follow Peter et al. (2015), who adapted the typical design used in adult priming studies, using as many within-participant variables as possible such that each participant would be exposed to all experimental conditions.

3 The Bingo game was adapted from Rowland et al. (2012) and Peter et al. (2015).

4 For a justification for the use of optimizers in such analyses, see Darmasetiyawan et al. (2022) and Linck and Cunnings (2015).

5 Effects of 'age group' are based on a sum contrast, with each age group getting compared to the grand mean of all four groups (based on Schad et al. 2020).

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5.3 Publication 3

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Abstract

The present study investigates how abstract structural representations in bilingual children develop with increasing age. We report the results from a structural priming experiment investigating lexically-independent priming and lexical boost effects for the German dative alternation in groups of 3-4, 5-6, and 7-8 year-old bilingual children and adult bilingual controls. Even though the prepositional-object structure is rare in German, lexically-independent priming effects emerged for all age groups except for 3-4 year-olds, who only showed a non-significant trend towards structural priming. This suggests that bilinguals already possess abstract syntactic representations even for rare structures. Lexical boost effects were absent in 3-4 year-olds, and only emerged with increasing age. In sum, the results closely resemble previous findings for monolingually-raised children. Cumulative priming effects, in contrast, were strongest in the youngest children, and gradually declined across age. We conclude that the development of abstract structural representations proceeds similarly in bilingual and monolingually-raised children.

Introduction

When children come across sentences with a productive syntactic structure for the first time, they have to understand that the structure is not specific to the particular words used within these specific sentences. With respect to this acquisition process, a prominent position holds that, when children gradually come across more sentences of the same type, they eventually create an abstract syntactic representation for the respective structure. For language acquisition in monolingually-raised children, a number of studies have provided evidence suggesting that monolingually-raised children already possess such abstract syntactic representations by the age of three, or possibly even earlier (e.g. Bencini & Valian, 2008; Branigan & McLean, 2016; Gamez & Schimpi, 2016; Huttenlocher, Vasilyeva & Shimpi, 2004; Kholodova et al., 2023; Kidd, 2012a, 2012b; Rowland, Chang, Ambridge, Pine & Lieven, 2012; Thothathiri & Snedeker 2008). The development of abstract structural representations in *bilingual* children, in contrast, has only been investigated in a relatively small number of studies. This constitutes the focus of the present study.

Language development in bilingual children

There is substantial evidence that bilingual language development involves the same stages and landmarks as language development in monolingually-raised children (see Genesee, 2015, for a review). However, bilingual language development is potentially special with respect to two important properties: First, the acquisition of a particular linguistic phenomenon may be affected by linguistic properties of a bilingual child's other language. Whether language acquisition is affected by *cross-linguistic influence* of this kind or not depends on a number of factors, such as linguistic domain and phenomenon, language dominance, and L2 onset (e.g. Serratrice, 2013). Second, given that the linguistic input experienced by bilingual children is split between their two languages, bilingual children necessarily receive substantially less input within each language than monolingually-raised children. This reduced amount of input may potentially affect language acquisition. For instance, at least some studies on the acquisition of vocabulary suggest that bilingual children possess smaller vocabulary within each of their languages than monolingually-raised children of the same age (see Bialystok, 2010, and much subsequent work). The present study investigates to what extent the reduced amount of input experienced by bilingual children may also affect the development of abstract representations for syntactic structures.

Structural priming as a tool for studying abstract structural representations in children

To investigate the development of abstract structural representations in children empirically, a number of studies have used *structural priming* paradigms. Typically, children play a game which involves listening to a *prime* sentence such as (1a) or (1b) (from Peter, Chang, Pine, Blything, & Rowland, 2015). In this example, both sentences use the ditransitive structure and contain the same content words. However, sentence (1a) contains a prepositional-object (henceforth PO) structure, while sentence (1b) is based on a double-object (henceforth DO) structure.

(1a) The king brought a cat to the queen. (PO structure)

(1b) The king brought the queen a cat. (DO structure)

Shortly after processing the prime sentence, children produce a *target* sentence describing a picture or video that could be described with either structure. If children already possess abstract structural representations for the PO and DO structures, these representations should get activated during processing of the prime sentence and lead to an increased likelihood of reusing the primed structure when producing the target.

Structural priming in monolingually-raised children has been extensively investigated, for PO versus DO structures (Huttenlocher, Vasilyeva, & Shimpi, 2004; Kholodova, Peter, Rowland, Jacob, & Allen, 2023; Morris & Scheepers, 2015; Peter et al., 2015a; Rowland, Chang, Ambridge, Pine, & Lieven, 2012; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007; Tafuri & Messenger, 2024; Thothathiri & Snedeker, 2008; see Kumarage, Donnelly, & Kidd, 2024, for a recent meta-analysis) as well as active versus passive structures (Bencini & Valian, 2008; Branigan & McLean, 2016a; Gámez & Schimpi, 2016; Huttenlocher, Vasilyeva, & Shimpi, 2004; Kidd, 2012a, 2012b; Messenger, Branigan, & McLean, 2011, 2012; Savage, Lieven, Theakston, & Tomasello, 2003, 2006; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007; Tafuri & Messenger, 2024). The majority of these studies confirm that children between three and six years of age already show structural priming effects. This is generally considered robust evidence for the above-mentioned claim that monolingually-raised children possess abstract representations for syntactic structures at this age.

Research on the development of abstract structural representations in *bilingual* children, however, is still relatively rare. Although a small number of studies (Unsworth, 2023; Wolleb, 2015; Wolleb, Sorace & Westergaard, 2018) have found evidence for abstract priming in bilingual children, these studies were primarily designed to investigate *cross-linguistic* priming, i.e. priming effects when the language of the prime sentence differs to the language in the target sentence. In such experiments, the key research question is to what extent existing syntactic representations for particular structures are shared between the two languages of a bilingual, with within-language priming conditions serving as control conditions. This makes it difficult to compare the results from these studies to those for monolingually-raised children discussed above. While cross-linguistic priming effects also constitute evidence for abstract structural representations, most of these studies investigated older children at age 5-6 or older, for whom it is largely uncontroversial that they already possess abstract structural representations. Also, none of these studies have systematically investigated how priming effects change with increasing age. Finally, the existing cross-linguistic priming studies often show a complex pattern of results, which is difficult to interpret with respect to the exact nature of the underlying representations. For instance, Vasilyeva et al. (2010) found priming effects only from L1 to L2, but not from L2 to L1. In sum, it is largely unclear whether bilingual children at the age of 3-4 already possess abstract representations for syntactic structures and how these representations develop further in older children.

Previous studies on structural priming in adults and monolingually-raised children have identified several factors which modulate the size of the priming effect. For instance, at least in adult speakers, priming effects are typically enhanced when prime and target share the same lexical head, such as the head verb, a finding referred to as the *lexical boost effect*. Lexical boost effects have not only occurred for adult native speakers, but also for L2 processing in adult late bilinguals, even at low proficiency levels (Bernolet et al., 2013; Coumel, Muylle, Messenger & Hartsuiker, 2024; Kim & McDonough, 2008, 2016; McDonough, 2006; Schoonbaert, Hartsuiker, & Pickering, 2007).

While lexical boost effects in adults are largely uncontroversial, priming studies with children have yielded inconsistent results for the lexical boost and its development with increasing age (Branigan & McLean, 2016; Kholodova, Peter, Rowland, Jacob & Allen, 2023; Kumarage, Donelly & Kidd, 2022; Peter, Chang, Pine, Blything & Rowland, 2015; Rowland, Chang, Ambridge, Pine & Lieven, 2012). Two recent child priming studies which investigated how structural priming and the lexical boost change with increasing age (Kholodova et al., 2023; Kumarage et al., 2022) found that children at the age of 3-4 showed structural priming,

but no lexical boost. Instead, the lexical boost only emerged with increasing age, while structural priming as such was consistently found across all age groups. Another key finding is that structural priming effects are typically enhanced for structures which are unexpected, for instance because they are infrequent in the language and thus only rarely encountered. This finding is generally referred to as *prime surprisal* (Jaeger & Snider, 2008; 2013) and suggests that statistical properties of a structure in the input (i.e. how frequently a structure is typically encountered in everyday life) can influence the magnitude of the priming effect (Bernolet & Hartsuiker, 2010; Branigan & McLean, 2016; Kaan & Chun, 2018; Kidd, 2012a, 2012b; Messenger, 2021; Peter et al., 2015; Tafuri & Messenger, 2024). Finally, repeated exposure to multiple primes typically causes stronger priming, an effect commonly referred to as *cumulative priming* (e.g. Jaeger & Snider, 2008; 2013).

While structural priming can be utilized as a methodological approach to investigate abstract structural representations, the *phenomenon* of structural priming (i.e. the fact that speakers tend to repeat grammatical structures previously encountered) is also discussed as a potential learning mechanism. Based on the observation that structural priming effects can persist for a substantial amount of time (e.g. Kaschak, Kutta, & Coyle, 2014; Kaschak, Kutta, & Schatschneider, 2011), the *Implicit Learning Account* (Bock & Griffin, 2000; Chang, Franklin, Gary, Dell & Bock, 2000; Chang, Dell, and Bock 2006) proposes a connection between structural priming and learning. Importantly for our purposes, the account offers a theoretical framework for the explanation of key effects typically observed in priming experiments, such as cumulative priming, lexical boost effects, and surprisal effects. The account is based on the key assumption that the parser continuously keeps track of how often a particular structure is encountered, with each exposure causing long-term changes to the respective structural representation. Immediate priming effects for structural alternations such as the dative alternation are assumed to be caused by the fact that processing of a prime sentence increases the number of encounters with this structure by one, slightly altering the PO/DO ratio in favor of the primed structure. Importantly, the parser uses this ratio to predict the upcoming sentence. For instance, while processing a German ditransitive sentence, the parser would likely predict the default DO structure. If the prime is a DO, this increases the amount of exposure to the DO structure by one. However, if the prime is a PO, priming is stronger due to the unexpected structure, causing a surprisal boost and a more substantial change to the PO/DO ratio. This change in frequency ratio should also lead to cumulative priming effects, with stronger priming when a less expected structure is primed repeatedly. Finally, with respect to the lexical boost, the account assumes that lexical boost effects emerge because lexical

similarity between prime and target serves as a memory cue for the previously activated sentential structure, boosting structural priming effects. For lexical boost effects in children, given that memory capacity in children improves with increasing age, this would predict that lexical-boost effects should gradually become stronger with age, with a smaller or no lexical boost in younger and gradually stronger lexical boost effects in older children.

The present study

The current study uses a structural priming paradigm to investigate the development of abstract syntactic representations and the lexical boost for the German dative alternation in bilingually-raised children across three age groups (3-4, 5-6, 7-8) and adults. Materials, experimental design, and procedure for our study were adopted from Kholodova et al.'s (2023) study investigating structural priming for the German dative alternation in monolingually-raised children and adult controls. The key results from their study were that (a) both immediate and cumulative structural priming effects emerged in all age groups, and (b) lexical boost effects only gradually emerged with increasing age.

The German dative alternation constitutes a particularly interesting phenomenon with regard to the development of abstract syntactic representations in children because, unlike English, German is strongly biased in favor of the DO structure. As a result, even monolingually-raised children at the age of 3-4 only rarely encounter the alternative PO structure (Kholodova and Allen, 2022). Bilingual children, who are exposed to less German input overall, may encounter sentences with the German PO structure even less often than monolingually-raised children.

If bilingual children already possess abstract structural representations for both PO and DO structures despite the fact that the PO structure is only very rarely encountered, we would expect robust immediate priming and cumulative priming across all age groups. In this case, the fact that bilingual children are typically only rarely exposed to the German PO structure may even cause a surprisal boost, with especially robust priming in younger participants. However, if the formation of abstract structural representations requires a minimum amount of exposure to the respective structure, bilingual 3-4 year-olds may not yet have encountered the German PO structure often enough. In this case, structural priming effects should not occur in this age group yet, and should instead only emerge with increasing age.

With respect to lexical boost effects, if the lack of a lexical boost in younger child groups (as observed in several previous monolingual studies) is caused by limited memory resources

in younger children, bilingual children (who presumably do not differ from monolingually-raised children with respect to the development of fundamental language-independent cognitive abilities such as memory capacity) should show a similar developmental trajectory for the lexical boost as monolingually-raised children. Following this rationale, we expect lexical boost effects to only gradually emerge with age, due to improving memory capacity in older children.

Finally, it is possible that the development of abstract structural representations in bilingual children is affected by properties of a bilingual's other language. Perhaps most importantly, it may be easier to form an abstract representation for the rare German PO if a similar structure exists in a bilingual's L1. To control for this kind of cross-linguistic influence, whether the PO structure exists in each bilingual's L1 or not was included as an additional predictor in the analyses.

Method

Participants. A total of 164 bilingual participants took part in the study. We recruited thirty-nine 3-4 year-olds (mean age=4.3; SD=0.49), fifty-two 5-6 year-olds (mean age=5.8; SD=0.67) and thirty-four 7-8 year-olds (mean age=7.9; SD=0.65) from nurseries and schools in the area. The adult group consisted of thirty-nine adults (mean age=24.9, SD=3.50) recruited from the University of Kaiserslautern-Landau student community, who participated for payment and were tested in a university laboratory. Three children were excluded prior to data analysis because they were raised in a monolingual environment.

For the participants from the three child groups, the parents gave informed consent for participation and filled out a language background questionnaire. For the groups of 3-4 and 5-6 year-olds, we also conducted the TROG-D test (Fox-Boyer, 2020) as a measure of German grammar proficiency. Biographic information for each age group is provided in Table 1. While the children came from a variety of different L1 backgrounds, the number of participants whose L1 does and does not allow for a PO structure was roughly balanced within all four age groups.

Table 1[1]**.** *Participant information by age group.*

	participant group			
	3-4 year-olds	***5-6 year-olds***	***7-8 year-olds***	***adults***
No. of participants	39	52	34	39
Mean age in months	51.28 (SD=5.60)	69.85 (SD=5.97)	95.59 (SD=7.79)	299.77 (SD=41.31)
Gender	17 female, 22 male	24 female, 28 male	15 female, 19 male	20 female, 19 male
Mean age in months at the start of living in Germany	3.72 (SD=11.60)	13.78 (SD=22.58)	25.31 (SD=29.23)	206.80 (SD=108.22)
Mean age in months when entering childcare in Germany	25.00 (SD=9.53)	34.08 (SD=12.84)	39.84 (SD=16.58)	—
Mean standardized receptive grammar test (TROG-D) T-score[2]	60.1 (SD=16.8)	53.5 (SD=11.6)	—	—
Hours of exposure to German per week in day care/school	36.1 (SD=5.79)	37.4 (SD=8.51)	38.4 (SD=11.7)	—
Hours of exposure to German per week in conversations with mother and father	36.2 (SD=18.9)	27.6 (SD=13.9)	35.5 (SD=23.8)	—
No. of participants born in Germany	26	30	15	0
No. of simultaneous bilinguals	24	17	15	1
No. of trilinguals	8	7	8	3
No. of participants with PO in L1	21	27	17	21
No. of participants without PO in L1	16	21	13	17
No. of participants whose L1 properties could not be determined	2	4	4	1

Design. Experimental stimuli and design were taken from Kholodova et al.'s (2023) study with monolingually-raised children, allowing for a direct comparison between studies. The study was based on a 4 (age group) x 2 (prime type) x 2 (verb condition) mixed design,

[1] Table 1 provides an overview of relevant biographic information by age group. See OSF for detailed individual biographic information.

[2] Proficiency scores are measured on a T-scale and reflect a child's individual proficiency relative to a norming sample of monolingual children of the same age. Thus, scores cannot be compared between different age groups.

with *'Age Group'* (3-4 year-olds, 5-6 year-olds, 7-8 year-olds, and adults) as a between-subjects variable and *'Prime Type'* (DO prime versus PO prime) and '*Verb Condition*' (different verbs in prime and target (DV) versus same verb in prime and target (SV)) as within-subjects variables. In addition, '*trial*' was included in the analyses as a continuous independent variable, to check whether priming effects may increase during the experiment.

Materials. Each prime sentence contained one of the four ditransitive German verbs *bringen* 'bring', *geben* 'give', *schicken* 'send', and *verkaufen* 'sell'. Four pairs of cartoon characters acted as agents and recipients: Dora and Boots (from *Dora the Explorer*), Wendy and Bob (from *Bob the Builder*), Jake and Izzy (from *Jake and the Never Land Pirates*), and Mickey and Minnie (from Disney cartoons). As themes, we selected six small animals that could easily be transferred from the agent to the recipient: *Hase* 'rabbit', *Hund* 'dog', *Papagei* 'parrot', *Schmetterling* 'butterfly', *Frosch* 'frog', and *Fisch* 'fish'.

To create prime sentences, the agent-recipient pairs and themes were first combined to create 16 character groupings (e.g. *Dora-Boots-Hase*). Within these, each agent-recipient pair occurred four times and each of the six themes either three or four times. Each of the four verbs was then assigned to four of the 16 groupings, so that each verb occurred together with each agent-recipient pair exactly once. The resulting 16 word groupings were subsequently used to create 16 experimental prime sentences. Each of the 16 prime sentences was then assigned a prime picture displaying the characters and action described in the prime sentence, and a target picture displaying an event which could be described with a ditransitive German sentence. Target pictures were assigned so that agent, recipient, and theme were never the same in a prime and its corresponding target. Finally, four versions of each prime sentence (i.e. PO+DV, DO+DV, PO+SV, DO+SV) were created. The resulting 4 x 16 = 64 experimental prime-target pairs were distributed across four presentation lists according to a Latin square design, with each of the four lists containing exactly one version of the four versions of each item. Each presentation list contained a total of 16 experimental items, four items from each of the four conditions. We also included 16 intransitive filler pairs (with sentences such as *Dora is jumping*.) in-between ditransitive prime-target pairs. During testing, each participant was randomly assigned to one of the four presentation lists. This ensured that no participant encountered an item in both its PO and DO versions.

Procedure. All children were tested in their nursery schools in a separate room.

The experiment was presented to the children as a bingo game. Prior to the experimental session, the experimenter introduced the cartoon characters to the child.

During the experimental trials, the main experimenter and the child sat next to each other in front of a laptop screen and described videos in turns. A second experimenter held up a hand puppet named Mobi, who had a set of bingo cards depicting some of the video actions. Each trial started with the presentation of a prime picture on screen, for which the main experimenter produced a corresponding prime sentence (e.g., *Dora schickt den Hasen zu Boots* 'Dora sends the rabbit to Boots'). The participant was then asked to repeat the sentence, with the explanation that Mobi could only comprehend child speech. The prime picture disappeared and the target picture came up on screen. To prompt a target description, the main experimenter produced a target fragment consisting of a subject and a verb (e.g., *Jake schickt …* 'Jake sends…'). The participant repeated subject and verb, and then completed the sentence on their own. This fragment completion technique ensured that participants would use the target verb, even if the action could be described with a different verb (Pickering & Branigan, 1998). If the child produced an incomplete target structure, the main experimenter provided additional encouragement to produce a sentence, using phrases designed not to bias the response in favor of any structural option (e.g., 'Please name all characters/objects on the screen', 'Please describe the whole action in one sentence', 'Can you include him/her in the sentence?'). After either the participant or the main experimenter produced a sentence, Mobi handed over a card to fill the bingo grid of each player if the sentence produced matched one of his cards. For the 7-8 year-olds and adults, no second experimenter was present. Instead, the experimenter or participant put a stamp on the Bingo grid when a happy face was displayed on the laptop screen. The system of filling up the grids was the same across all groups, with the participant always emerging as the winner.

The experiment started with a practice session consisting of intransitive 5 practice trials which allowed the child to get used to the experimental procedure. After this practice session, participants went through a baseline pretest designed to test their baseline preferences for producing DO versus PO structures when not primed by POs or DOs. The pretest consisted of four target pictures which were preceded by intransitive prime sentences (e.g. 'Wendy is swinging.'). After the baseline pretest, 7-8 year-olds and adults immediately continued with the actual experiment; for 3-4 and 5-6 year-olds, the experiment was split into two sessions, with the participants going through the TROG-D, practice session, and baseline pretest in the first session and the actual experiment in the second session.

After the experiment, all children received a 'Thank You' bread box with the project and university logo and were given a 'Bingo Game Champion' certificate.

Coding. The initial raw data set consisted of a total of 3280 target sentences. These were coded as either DO, PO, or OTHER. A target was coded as a DO when the verb was followed by an indirect object and then by a direct object, without any prepositions (NP_NP; e.g., *Bob den Hasen* 'Bob the rabbit') or when the two objects were scrambled (NP_NP; e.g., *den Hasen Bob* 'the rabbit Bob'; N=329; 10.0% of all utterances). Target utterances were coded as a PO when the verb was followed by a direct object and then by a prepositional indirect object (NP_PP; e.g., *den Hasen an Bob* 'the rabbit to Bob') even if the preposition was wrong (N=168; 5.1%) or when the two objects were scrambled (PP_NP; e.g., *an Bob den Hasen* 'to Bob the rabbit'; N=101; 3.1% of all utterances). Any target responses not conforming to the above designation as PO or DO were coded as OTHER (N=150; 4.6%) and were excluded from the analysis. We followed Peter et al.'s (2015) approach of coding the data according to a *strict,* an *intermediate*, and *a lax* coding scheme. To comply with the strict coding scheme, the child had to use the correct verb, the modeled prepositions *an* and *zu* (for PO sentences), and the sentence had to be produced after a maximum of only one prompt to repeat the prime sentence. For intermediate coding, more than one prompt was allowed. Additionally, in the DV conditions, the sentences were still scored as POs and DOs when the child produced a different target verb, and any types of prepositions were accepted (with the exception of the preposition *von* 'of/from', which indicates that the NP does not refer to a recipient). Finally, the criteria for lax coding were similar to intermediate coding except that any ditransitive verbs or prepositions not incorporated in the design were accepted. As the three coding schemes showed a similar pattern of effects, only the results from the strict coding scheme are reported.

Results

Baseline pretest. Consistent with the general bias in favor of the DO structure in German, all groups produced more DOs than POs in the baseline pretest. This DO bias was stronger in 3-4 year-olds (76% DOs vs. 24% POs) and 5-6 year-olds (80% DOs vs. 20% POs) than in 7-8 year-olds (59% DOs vs. 41% POs) and adults (56% DOs vs. 44% POs).

Structural priming effects and the lexical boost. Table 2 shows the mean proportion of PO responses (relative to the sum of all PO and DO responses) by prime type (PO prime vs. DO prime) and verb condition (different verb vs. same verb in prime and target) for each of the four age groups.

Table 2. *Proportion of PO responses (out of the sum of all PO and DO responses) by condition and age group.*

	different verb		same verb		amount of priming (different verb)	amount of priming (same verb)	lexical boost
	DO prime	PO prime	DO prime	PO prime			
3 to 4	35.4%	48.6%	35.8%	50.7%	13.2%	14.9%	1.7%
5 to 6	36.7%	43.6%	32.2%	51.1%	6.9%	18.9%	12.0%
7 to 8	57.7%	70.3%	54.8%	79.3%	12.6%	24.5%	11.9%
adults	51.7%	63.0%	31.3%	89.5%	11.3%	58.2%	46.9%

We analyzed the data with a generalized linear-mixed effects model predicting the structure produced in the target (Baayen et al., 2008; Barr Levy, Scheepers, and Tily, 2013; Jaeger, 2008). Analyses were carried out in R version 4.2.1 (R Core Team, 2019) using *glmer* in the *lme4* package (e.g., lme4 version 1.1-30). The model contained '*prime type (DO prime vs. PO prime)*', '*verb condition (same verb vs. different verb in prime and target)*', *'age group*', '*trial*', and their interactions, as fixed effects. For the four-level predictor '*age group*', we assigned a baseline contrast, with the group of 3-4 year-olds serving as the baseline age group. As a result, the model contains pairwise comparisons between the 3-4 year-olds and each of the three other age groups.

As suggested by Barr et al. (2013), the model contained a maximal random-effects structure, with by-subject and by-item random intercepts and slopes for all categorical predictors. We applied the optimizer *bobyqa* (bound optimization by quadratic approximation) taken from the *nloptr* package. The results from this model analysis are shown in Table 3.

Table 3. *Results from the generalized linear-mixed-effects model on the PO production as a function of 'prime type'. 'verb condition'. 'trial', and 'age group'.*

Fixed effect	*estimate*	SE	*z*	*p*
intercept	-0.55	0.44	-1.26	.208
prime type (in baseline age group, i.e. in 3-4 year-olds)	0.59	0.37	1.59	.111
verb condition (in baseline age group)	0.09	0.35	0.25	.800

trial (in baseline age group)	0.18	0.04	4.14	**<.001**	***
age group (3-4 vs. 5-6)	0.07	0.56	0.13	.900	
age group (3-4 vs. 7-8)	1.78	0.63	2.84	**.005**	**
age group (3-4 vs. adults)	1.23	0.57	2.17	**.030**	*
*prime type * verb condition*	-0.04	0.72	-0.06	.954	
*prime type * trial*	0.04	0.08	0.46	.646	
*verb condition * trial*	-0.02	0.08	-0.22	.828	
*prime type * age group (3-4 vs. 5-6)*	0.20	0.44	0.46	.647	
*prime type * age group (3-4 vs. 7-8)*	0.62	0.45	1.38	.169	
*prime type * age group (3-4 vs. adults)*	1.93	0.45	4.29	**<.001**	***
*verb condition * age group (3-4 vs. 5-6)*	-0.21	0.41	-0.51	.612	
*verb condition * age group (3-4 vs. 7-8)*	0.16	0.42	0.38	.704	
*verb condition * age group (3-4 vs. adults)*	0.28	0.41	0.67	.501	
*trial * age group (3-4 vs. 5-6)*	-0.06	0.05	-1.23	.218	
*trial * age group (3-4 vs. 7-8)*	-0.13	0.06	-2.40	**.016**	*
*trial * age group (3-4 vs. adults)*	-0.10	0.05	-2.09	**.036**	*
*prime type * verb condition * trial*	-0.14	0.16	-0.86	.389	
*prime type * verb condition * age group (3-4 vs. 5-6)*	0.99	0.84	1.18	.239	
*prime type * verb condition * age group (3-4 vs. 7-8)*	1.17	0.86	1.37	.172	
*prime type * verb condition * age group (3-4 vs. adults)*	3.74	0.85	4.42	**<.001**	***
*prime type * trial * age group (3-4 vs. 5-6)*	-0.10	0.10	-1.07	.286	
*prime type * trial * age group (3-4 vs. 7-8)*	-0.15	0.10	-1.52	.128	
*prime type * trial * age group (3-4 vs. adults)*	-0.02	0.09	-0.23	.822	
*verb condition * trial * age group (3-4 vs. 5-6)*	0.15	0.10	1.57	.117	
*verb condition * trial * age group (3-4 vs. 7-8)*	0.01	0.10	0.06	.956	
*verb condition * trial * age group (3-4 vs. adults)*	0.01	0.09	0.10	.920	
*prime type * verb condition * trial * age group (3-4 vs. 5-6)*	0.07	0.19	0.36	.719	
*prime type * verb condition * trial * age group (3-4 vs. 7-8)*	0.03	0.19	0.14	.893	
*prime type * verb condition * trial * age group (3-4 vs. adults)*	0.22	0.19	1.20	.230	

Based on 1901 observations. Strict coding; LogLik = -901.3. Fixed and random effect structure: PO ~ prime type * verb condition * trial * age group + (prime type * verb condition | subject) + (prime type * verb condition + age group | Item)

The model showed a significant two-way interaction between '*prime type*' and '*age group*' for the comparison between 3-4 year-olds and adults, with stronger priming in adults than in 3-4year-olds. The nature of this two-way interaction is clarified by the significant three-way interaction between '*prime type*', '*verb condition*' and '*age group (3-4- year-olds vs. adults)*', indicating that the stronger priming in adults, compared to 3-4 year-olds, is primarily carried by the same-verb condition: The adults showed a substantial lexical boost effect, which increased priming in all trials in which prime and target shared the same verb, while the 3-4 year-olds showed no lexical boost.

With respect to cumulative priming effects, the model revealed a significant main effect of '*trial*' for the baseline age group, with the proportion of POs produced by 3-4year-olds gradually increasing during the experimental session. The results also showed significant two-way interactions between '*trial*' and '*age group*', with a stronger effect of '*trial*' in 3-4 year-olds than in 7-8 year-olds and adults.

Finally, with regard to the overall proportions of POs produced by each age group irrespective of *'prime type'*, *'verb repetition'*, and *'trial'*, the model revealed significant differences between 3-4 year-olds and 7-8 year-olds and between 3-4 year-olds and adults, in both cases with 3-4 year-olds producing relatively fewer PO targets.

To investigate the nature of the significant interactions in the omnibus analysis in more detail, we conducted additional, separate model analyses for each age group. To control for the potential influence of grammatical properties of the L1 in these analyses, we coded, for each participant, whether the PO structure constituted a grammatical option in the participant's L1 or not, and included this property (henceforth '*PO in L1'*) as an additional binary predictor[3]. The results from this analysis are shown in Table 4.

Table 4. *Priming effects within each age group.*

		estimate	SE	*z*	*p*
3 to 4	*intercept*	-1.02	0.69	-1.48	.139
	prime type	1.19	0.81	1.47	.142

[3] We decided against including '*PO in L1*' in the main omnibus analysis reported in Table 2 because the distribution of '*PO in L1*' was not exactly the same across age groups. The resulting correlation between '*PO in L1*' and '*age group*' would have caused collinearity problems in an omnibus analysis including both '*PO in L1*' and '*age group*' as predictors.

	verb condition	0.10	0.45	0.22	.826	
	trial	0.23	0.06	3.98	**<.001**	***
	PO in L1	-1.12	1.36	-0.82	.411	
	*prime type * verb condition*	0.08	0.91	0.09	.931	
	*prime type * trial*	-0.08	0.12	-0.64	.523	
	*verb condition * trial*	0.07	0.11	0.63	.529	
	*prime type * PO in L1*	0.94	1.41	0.67	.503	
	*verb condition * PO in L1*	2.68	0.89	3.01	**.003**	**
	*trial * PO in L1*	-0.05	0.11	-0.44	.660	
	*prime type * verb condition * trial*	-0.29	0.24	-1.23	.221	
	*prime type * verb condition * PO in L1*	-2.99	1.76	-1.70	.089	.
	*prime type * trial * PO in L1*	-0.12	0.21	-0.56	.575	
	*verb condition * trial * PO in L1*	0.01	0.21	0.05	.962	
	*prime type * verb condition * trial * PO in L1*	-0.47	0.41	-1.13	.257	
5 to 6	*intercept*	-0.88	0.66	-1.33	.183	
	prime type	1.22	0.61	2.00	**.046**	*
	verb condition	-0.71	0.58	-1.24	.217	
	trial	0.17	0.05	3.27	**.001**	**
	PO in L1	-0.42	1.30	-0.32	.746	
	*prime type * verb condition*	2.09	1.34	1.56	.120	
	*prime type * trial*	-0.17	0.10	-1.73	.084	.
	*verb condition * trial*	0.24	0.11	2.27	**.023**	*
	*prime type * PO in L1*	0.59	1.12	0.53	.598	
	*verb condition * PO in L1*	-0.18	1.02	-0.18	.858	
	*trial * PO in L1*	-0.06	0.09	-0.64	.524	
	*prime type * verb condition * trial*	-0.22	0.20	-1.09	.275	
	*prime type * verb condition * PO in L1*	-1.37	2.66	-0.51	.608	
	*prime type * trial * PO in L1*	-0.03	0.18	-0.15	.880	
	*verb condition * trial * PO in L1*	0.16	0.18	0.89	.373	
	*prime type * verb condition * trial * PO in L1*	-0.02	0.36	-0.05	.960	
7 to 8	*intercept*	1.08	0.46	2.37	**.018**	*
	prime type	1.40	0.36	3.90	**<.001**	***
	verb condition	0.52	0.34	1.52	.129	
	trial	0.02	0.05	0.51	.612	
	PO in L1	0.94	0.70	1.35	.178	
	*prime type * verb condition*	1.53	0.67	2.27	**.023**	*
	*prime type * trial*	-0.13	0.07	-1.82	.069	.
	*verb condition * trial*	-0.06	0.09	-0.74	.461	
	*prime type * PO in L1*	-0.63	0.68	-0.93	.354	
	*verb condition * PO in L1*	-0.55	0.62	-0.89	.374	
	*trial * PO in L1*	-0.19	0.07	-2.75	**.006**	**
	*prime type * verb condition * trial*	-0.11	0.14	-0.78	.437	

	*prime type * verb condition * PO in L1*	-0.42	1.22	-0.35	.730	
	*prime type * trial * PO in L1*	-0.06	0.13	-0.46	.646	
	*verb condition * trial * PO in L1*	0.12	0.13	0.89	.375	
	*prime type * verb condition * trial * PO in L1*	0.03	0.27	0.11	.916	
adults	*intercept*	0.49	0.31	1.60	.110	
	prime type	2.48	0.36	6.90	**<.001**	***
	verb condition	0.49	0.27	1.80	.072	.
	trial	0.08	0.03	2.51	**.012**	*
	PO in L1	-0.98	0.56	-1.76	.078	.
	*prime type * verb condition*	3.80	0.60	6.33	**<.001**	***
	*prime type * trial*	-0.02	0.06	-0.25	.804	
	*verb condition * trial*	0.03	0.06	0.48	.635	
	*prime type * PO in L1*	0.70	0.60	1.17	.242	
	*verb condition * PO in L1*	0.48	0.54	0.89	.375	
	*trial * PO in L1*	0.01	0.06	0.16	.870	
	*prime type * verb condition * trial*	0.08	0.13	0.63	.527	
	*prime type * verb condition * PO in L1*	-0.29	1.14	-0.25	.801	
	*prime type * trial * PO in L1*	-0.01	0.11	-0.07	.946	
	*verb condition * trial * PO in L1*	-0.02	0.11	-0.14	.885	
	*prime type * verb condition * trial * PO in L1*	-0.08	0.22	-0.36	.718	

The results from these follow-up analyses showed significant main effects of '*prime type*' for all groups except for the 3-4 year-olds, who only showed a non-significant numerical trend (p=.142) towards a priming effect.

As for the lexical boost, the two-way interaction between '*prime type*' and '*verb condition*' was non-significant for the 3-4 year-olds (p=.931) and for 5-6 year-olds (p=.120), but significant for both 7-8 year-olds and adults. This suggests that the lexical boost effect may only gradually emerge with increasing age.

With respect to cumulative priming during the experiment, all groups except for the 7-8 year-olds showed significant main effects of '*trial*', with an increasing proportion of POs produced as the experiment proceeded.

Finally, regarding a possible influence of grammatical properties of the L1 (in this case, whether the rare PO structure existed in a participant's L1 or not), the fact that the interactions between '*prime type*' and '*PO in L1*' were non-significant in all four age groups suggests that the effect of '*prime type*' was not substantially affected by L1 influence.

Statistical comparison with monolingually-raised children. The fact that our study used the same materials, experimental design, and age groups as Kholodova et al.'s (2023) study on priming effects in monolingually-raised children makes it possible to directly compare the effects for the two participant groups. We thus obtained the raw data from this monolingual study and conducted additional model analyses on the combined bilingual and monolingual data for each age group, with '*participant group* (*bilingual vs. monolingual)*' as an additional categorical predictor. The combined data set showed significant main effects of '*prime type*' for all three child groups as well as for adults (all *p*s < .01). Crucially, the two-way interactions between '*prime type*' and '*participant group'* were clearly non-significant for all age groups. Lexical-boost effects (i.e. interactions between '*prime type*' and '*verb condition*' were only significant for 7-8 year-olds and adults (both *p*s < .05). All interactions between the lexical boost and 'participant group' were again non-significant in all age groups. Thus, the combined analysis showed highly similar developmental trajectories in bilinguals and monolinguals for both the priming effect as such and the lexical boost.

Discussion

Our experiment tested structural priming effects and the lexical boost in bilingual children of different age groups. Crucially, our study investigated these effects for the German dative alternation, a structural alternation which is strongly biased towards one of the two structural alternatives. Given that the German PO structure is thus only rarely encountered, in particular in child speech, and also given that bilingual children experience less exposure to German in general than monolingually-raised children, the German dative alternation constitutes an ideal test case for whether the formation of abstract representations in children is affected by how often the respective structure was previously encountered.

Bilingual children and the general DO bias in German

In our baseline pretest, all four participant groups produced more DO than PO responses. This suggests that our bilingual participants, irrespective of age, were aware of the fact that the German dative alternation is strongly biased towards the DO structure (De Vaere, De Cuypere, & Willems, 2018; Kholodova & Allen, 2023). Note, however, that across all age groups, this DO bias was numerically weaker than in Kholodova et al.'s (2023) results for monolingually-

raised speakers. This observation is consistent with claims that structural biases may generally be weaker in bilinguals (e.g. Papadopoulou & Clahsen, 2003).

Bilingual Immediate priming effects and abstract representations across age groups

In the descriptive results, all four age groups showed numerical trends towards structural priming in both the '*same verb*' and '*different verb*' conditions, with more PO responses following PO primes than following DO primes. In the additional analyses for each age group, this effect of prime type was statistically significant for 5-6 year-olds, 7-8 year-olds, and adults, with 3-4 year-olds only showing a numerically similar but statistically non-significant trend towards structural priming (p=.142). This pattern is largely consistent with the findings from Kholodova et al.'s (2023) study with monolingual-raised German speakers, except that Kholodova's results showed significant immediate priming effects for all four age groups, including the 3-4 year-olds.

The fact that our bilingual 5-6 year-olds, 7-8 year-olds, and adults showed significant effects of the immediate prime constitutes evidence for the existence of abstract structural representations for German PO and DO structures in these three groups. For the group of 3-4 year-olds, this is not entirely clear, given that this age group only showed a non-significant numerical trend towards a priming effect. One possibility is that bilingual children at this age do not yet possess abstract structural representations for PO and DO structures, and that such representations are only acquired at a later age. Given that the group of monolingually-raised 3-4 year-olds tested by Kholodova et al. (2023) already showed significant priming, this could theoretically indicate that monolingually-raised children already possess abstract structural representations at this age, while bilingual children do not. However, we are reluctant to draw any strong conclusions about this, for several reasons: First, the priming effect in our bilingual 3-4 year-olds, while statistically non-significant, was numerically not weaker than in the older bilingual child groups (see the descriptive statistics in Table 2), and also not any weaker than in the monolingually-raised 3-4 year-old children tested by Kholodova and colleagues (for whom the priming effect reached significance). Also, the estimate for the non-significant effect of *'prime type'* in the 3-4 year-olds (1.19) was almost the same as for the significant effect of *'prime type'* in the 5-6 year-olds (1.22). Second, the claim that 3-4 year-olds do not yet possess abstract structural representations, and that such representations only emerge in 5-6 year-olds, predicts significant two-way interactions between '*prime type*' and '*age group*' for the

comparisons between the 3-4 year-olds and the two older child groups. In the omnibus model in Table 2, however, the two-way interactions comparing the size of the immediate priming effect in 3-4 year-olds versus in the two older child groups were clearly non-significant. Third, if it were indeed the case that monolingually-raised children already possess abstract PO representations while bilingual children do not, the comparison between bilingual and monolingually-raised 3-4 year-olds should have shown a significant interaction between '*prime type*' and '*participant group* (*bilingual versus monolingual)*'. However, the additional analyses comparing our results for the 3-4 year-olds with the monolingually-raised children from Kholodova et al. (2023) instead showed a significant main effect of '*prime type*' across all bilingual and monolingual participants, while the interaction between '*prime type*' and '*participant group*' was clearly non-significant. Finally, the 3-4 year-olds produced substantially more incomplete, ungrammatical, and missing responses than the older child groups, presumably because the bingo task was more challenging for them than for older children, resulting in reduced statistical power in the analyses for this age group. Thus, it is at least a possibility that bilingual children at this age already possess abstract structural representations, and that the immediate priming effect did not reach significance because of greater data loss, more noise in the data, and thus a reduced degree of statistical power, in this group. In addition to the main effects of prime type, the analyses also showed a significant two-way interaction between '*prime type*' and '*age group*' for the contrast between 3-4 and adults. This indicates a developmental trajectory for structural priming, with the priming effect gradually getting more robust with increasing age.

In sum, the observed results for the immediate priming effect and its developmental trajectory are similar to those reported by Kholodova et al. (2023), for monolingually-raised children, albeit with a not entirely clear result for the youngest age group. This suggests that the fact that bilingual children have experienced even less exposure to the rare German PO structure than monolingually-raised children may not make a fundamental difference when it comes to the formation of an abstract PO representation.

The lexical boost and its development across age

With respect to lexical boost effects, the main analysis revealed a significant three-way interaction between '*prime type*', '*verb repetition*', and '*age group*' for the contrast between 3-4 year-olds and adults, suggesting that the size of the lexical boost increases with age. The additional analyses for each age group corroborate this claim, with no lexical boost for 3-4 year-

olds, a marginally[4] significant lexical boost for 5-6 year-olds (p=.08), and significant lexical boost effects for 7-8 year-olds and adults. Our findings for the lexical boost are in line with Kholodova et al.'s (2023) results for monolingually-raised children, in which the lexical boost also only gradually emerged with age. This suggests a similar developmental trajectory for the lexical boost in monolingual and bilingual children. It is not clear yet which factors affect the exact onset of the lexical boost. For example, Kumarage et al.'s (2022) study on active/passive priming in English monolingual children also found a similar developmental trajectory, except that the lexical boost started to emerge at a slightly earlier age (54 months).

Our results for the lexical boost are consistent with the Implicit Learning account, which predicts that lexical boost effects should only emerge when children have developed sufficient memory resources. The account may also explain why the lexical boost effect emerged at a different age in different child priming studies: If the lexical boost indeed depends on memory resources, whether the effect emerges or not should depend on the memory demands of the particular linguistic phenomenon and experimental task. This may explain why some studies which have investigated the lexical boost in only one age group have found a lexical boost effect in children between age three and six (Branigan, McLean & Jones, 2005; Branigan & McLean, 2016b; Gerard & Keller, 2010; Morris & Scheepers, 2015; Savage, Lieven, Theakston, & Tomasello, 2003), while other studies with children from the same age range have not (Foltz, Thiele, Kahsnitz, & Stenneken, 2015; Peter et al., 2015; Rowland et al., 2012; Thothathiri and Snedeker, 2008).

While lexical boost effects in children are typically discussed with reference to memory resources, it deserves to be mentioned that theoretical accounts of structural priming in adults (see Pickering & Branigan, 1998, and much subsequent work) explain lexical boost effects through connections between abstract structural representations and lexical entries of verbs. In development, such connections may gradually become stronger, leading to stronger lexical boost effects with increasing age. This may constitute an alternative explanation for the developmental trajectory in our study.

Cumulative priming and adaptation to the PO structure during the experimental session

[4] Note that the term "marginally significant" has been subject to controversial debate. In this manuscript, we use the term in a purely descriptive way, to refer to effects with p-values between .05 and .1.

In addition to the effects of the immediate prime, the results from our main analysis also showed an effect of '*trial*', with a gradually increasing number of PO responses during the experimental session, in all age groups except for the 7-8 year-olds. This can be interpreted as a cumulative priming effect; the unusually high amount of exposure to PO sentences during the experiment led to increased production of POs during the experimental session in general, i.e. irrespective of whether the preceding immediate prime was a PO or DO.

With respect to differences in cumulative priming between age groups, note that the omnibus analysis in Table 2 also showed significant two-way interactions between *'trial'* and *'age group'*. This suggests that the size of the cumulative priming effect is affected by age, with the strongest cumulative priming effect in 3-4 year-olds, and weaker (and, for 7-8 year-olds, even non-significant) cumulative priming in older children. This suggests that the cumulative priming effect is also subject to a developmental pattern. Again, this is predicted by the Implicit Learning account, which claims that, due to prime surprisal, priming effects should be stronger for structures which have only rarely been encountered before. Following this rationale, and as observed in our study, cumulative priming effects should be particularly strong in 3-4 year-olds (who have experienced even less previous exposure to the rare PO structure than older children), and should get weaker with increasing age. Note, however, that while this is indeed the case for the three child groups in our study, cumulative priming actually increased again in the adult group, with adults showing a substantially stronger cumulative priming effect than the oldest child group. While this effect was not predicted, one possibility is that the effect of '*trial*' in the adult group is boosted by late, strategic processes based on metalinguistic knowledge: During the experimental session, at least some adult participants may gradually become aware that the study is likely about the generally rare German PO structure, and may thus adjust their structural choices during the production of target sentences accordingly. It is conceivable that a late, strategic effect based on metalinguistic knowledge is largely specific to the adult group. The developmental trajectory for the cumulative priming effect aside, the fact that the adult group showed a significant cumulative priming effect as such is consistent with the findings from previous studies investigating cumulative priming effects in bilingual and monolingually-raised adults (Jaeger and Snider, 2008; Kaan and Chun, 2018; Kaschak and Borreggine, 2008; Kaschak, Loney, and Borreggine, 2006; Kaschak et al., 2011). This once again aligns with the predictions of the Implicit Learning account, which claims that, given that the PO structure is rare in German, even adults should show a degree of adaptation to this rare structure, due to prime surprisal.

Structural priming effects and L1 influence

The fact that our results showed no significant interactions between '*prime type*' and *'PO in L1'* for any age group suggests that both immediate priming and the lexical boost effect were not affected by whether the PO structure exists in the participants' L1 or not. At first glance, this could be considered surprising, given the substantial amount of evidence for cross-linguistic structural priming effects in bilinguals (see van Gompel & Arai, 2018, for a review). However, unlike in a cross-linguistic priming experiment, the participants in our study were not tested in a language-switching situation. This is relevant because there is at least some evidence that effects of L1 influence mainly occur in situations where both languages of a bilingual are active simultaneously (e.g. Hopp, 2017; Jacob, 2009). Note also that the few existing studies investigating to what extent priming effects are affected by L1 influence suggest that, at least in bilingual adults, structural choices in L2 production are not affected by the distributional and linguistic properties of the L1 alternates of the structures investigated (Flett, Branigan & Pickering, 2013, McDonough, 2006). In any case, the participants in our study came from a wide variety of different L1 backgrounds. Thus, our study was not designed to investigate L1 influence, with *'PO in L1'* only included in the analyses as a control variable. Nonetheless, the fact that our results are very similar to Kholodova et al.'s (2023) results for monolingually-raised participants suggests that L1 influence is unlikely to be a crucial factor here.

Summary and conclusion

An important finding from the present study is that bilingual children acquire abstract structural representations in a similar way and at a largely similar pace as monolingually-raised children, despite the fact that they experience less exposure to the language. This suggests that the absolute number of encounters with a particular structure may not be particularly relevant for the development of abstract structural representations and that children immediately start forming abstract representations even for structures which are only rarely encountered and may not necessarily exist in their L1.

The development of abstract structural representations aside, priming effects in bilingual children have also been linked to grammatical language change (e.g. Pickering & Garrod, 2017). Such accounts assume that bilingual children are agents of language change,

and suggest that structural priming in bilingual children may constitute a psycholinguistic mechanism which allows new grammatical structures (which, for instance, have just emerged in the language through language contact within bilingual individuals) to consolidate themselves in the language through structural priming. Our study provides evidence for a crucial prerequisite for this suggestion, i.e. that bilingual children, at least from the age of 5-6 onwards and potentially already at the age of 3-4, possess the necessary abstract structural representations for rare structures which are responsible for structural priming effects.

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Chapter 6: General Discussion

6.1. Summary of the research

In the work covered in this dissertation, we examined the development of abstract and lexically dependent structural representations in both monolingual and bilingual children and adults. We investigated abstract representations using a structural priming paradigm, which has proven to be an effective method for assessing structural representations in adults and has also been applied successfully to children, although primarily in English. Our research sought to uncover important insights into the development of structural representations in languages that strongly favor one structural option over another. In the German language, this situation is evident with ditransitive structures, as the language predominantly favors the direct object (DO) structure, which leads to the prepositional object (PO) being employed much less frequently. Compared to constructions like passives (versus actives), the two ditransitive structures are relatively simple in syntax, making them easy for children to master. Thus, the factors that impede children from acquiring the rarer variant are more probabilistic in nature. It is important to note that a priming effect can only occur if a child has an abstract representation for a primed structure.

Our objective was to determine two things: (1) how the two structural alternatives are represented in a child's mind at base level across several developmental stages, given limited exposure to the less common variant, especially in young children, and (2) the extent to which the rarely used alternative construction can be increased in usage through abstract priming. Depending on how surprising the rarer option in the language is during the prime, children should exhibit stronger priming effects, as anticipated by the Implicit Learning Model, and show surprisal effects. Concerning bilingual children, it is not straightforward whether they are as sensitive as monolingual children to probabilistic information or probabilistic factors governing the language (here, German), and importantly, it is not clear whether they develop abstract representations for the two structures (DO and PO) as early as monolingually-raised children do.

As a second interest, we aimed to investigate lexically-dependent priming effects in this type of language, specifically focusing on the developmental trajectory of the lexical boost effect, which has been documented to evolve when the same lexical items are shared between the prime and the target. Although previous research has shown that adults exhibit stronger priming effects when lexical items such as the verb are shared between the prime and target, findings for children are limited and often contradictory. As a third focus, we were

interested in investigating whether there are surprisal effects and whether these differ across different age groups. According to the Implicit Learning Account, children with weaker structural representations and greater learning needs are hypothesized to show a stronger immediate priming effect. Finally, we addressed the gap in research regarding cumulative priming effects in children. Here, we are interested in understanding the longer-term development of priming effects—specifically, how the primed structure behaves throughout the experimental procedure. Addressing these questions is essential for a more thorough understanding of how abstract and lexically-dependent priming influences cognitive development in children, particularly in relation to probabilistic information at the syntax interface.

To study these questions, we needed to learn more about the language typology and the probabilistic frequencies with which the two German ditransitive structures are used in children across development and adults. To date, there is very little empirical research documenting these probabilities in either children or adults. While existing literature thoroughly investigates the emergence of structural representations for the German DO, it offers little information on the alternative PO construction, giving the impression that this structure is neglected. For these reasons, we first examined how the dative alternation in German is produced and comprehended by adults and how it develops with age in children. This exploration helped us to understand when and how children acquire and use ditransitive structures, as well as the frequency distributions of these structures in both children and adults. Additionally, because the literature makes strong claims about certain verbs exclusively taking the DO only, we examined the extent to which this applies to everyday speech in real interactions and to which extent both structures are accepted for the verbs of interest.

We developed a sentence completion task and a grammaticality judgment task for adults, and studied child and child-directed speech in corpora of five typically-developing German-speaking children aged 1;6–7;5, taken from the CHILDES database (MacWhinney, 2000). We chose seven ditransitive verbs well known by children (*geben* 'give', *bringen* 'bring', *schicken* 'send', *verkaufen* 'sell', *zeigen* 'show', *reichen* 'hand' and *werfen* 'throw') and studied how they behave.

For the child corpus study, our findings partially align with existing literature on language acquisition in English-speaking children. Specifically, we observed that the DO structure is produced by age three, with children acquiring the DO form before the PO form (Campbell & Tomasello, 2001; Huttenlocher et al., 2004; Snyder & Stromswold, 1997). Our

data even indicates the emergence of the DO structure in children as early as ages 2;0 to 2;11, predominantly using the verbs *geben* 'give' and *zeigen* 'show' (consistent with Woods, 2012). We noted only a few instances of other verbs being used in the ditransitive structure between ages 2;0 and 4;11. A key distinction in acquisition is that, while English-speaking children quickly pick up PO constructions around the same developmental period as DO structures, German-speaking children produce very few instances of the PO structure because they encounter the PO relatively rarely in their input (in line with Clahsen et al., 2006; Schönenberger et al., 2011; Woods, 2012). In our data, we found only two instances of PO structures produced by Leo—one with *geben* 'give' and one with *schicken* 'send.' Most ditransitives were produced with the verb *geben* 'give', followed by *zeigen* 'show' and *bringen* 'bring' around age 2;0 – 2;11, whereas ditransitives were produced much less frequently with other verbs throughout development, at least partially due to the lower overall frequency of use of those verbs. In line with numerous studies, our results also show that child-directed speech mirrors the language patterns of children (Goldberg, 2006; Lieven & Tomasello, 2008; Lieven et al., 1997; Tomasello, 2003). Due to limited token frequency for particular verbs in the corpus data, we were unable to gain broader insights into frequency patterns and alternation behavior for each verb under investigation.

For adult speech, then, we relied on results from the sentence completion task and the grammaticality judgement task. These were specifically designed to elicit frequencies of use for each alternation. They also provided further information on the preferences for the two prepositions (*an* and *zu*) associated with each verb, which indicate transfer in PO structures similar to the word 'to' in English. While the results confirmed the well-known observation that German is significantly DO-biased, there was evidence suggesting that certain verbs such as *geben* 'give' and *reichen* 'hand' – which have traditionally been considered restricted to the DO structure and only permitted in a PO structure in dialectal contexts or emphasis, tend to favor the PO alternative much more than previously documented in the literature. Although *geben* 'give' and *reichen* 'hand' were found to be produced predominantly with the DO structure (97.2% and 100% respectively), they were judged absolutely grammatical in the PO form with the preposition *an*.[1] The verbs *schicken* 'send' and *verkaufen* 'sell' were produced

[1] The verb *werfen* 'throw' was not included in the adult studies because child language data made clear that it was very often used with the particle *zu (*infinitive*: zuwerfen)*. For example, in a DO sentence *Der Mann wirft dem Jungen den Ball zu* 'The man throws the boy the ball', the presence of the particle does not follow the morpho-syntactic patterns of the rest of the verbs used in the study.

in the PO structure most often compared to other verbs, and *schicken* ‘send’ was even found to be PO-biased since 69.1% of sentence completions with *schicken* were produced with PO structures. In contrast, the verb *bringen* 'bring' showed a strong preference for the DO structure, featuring only a 12.3% likelihood of being used in the PO structure, whereas the verb *zeigen* 'show' was never produced in the PO structure in our studies, which aligns with existing literature on the topic.

Based on the results of all three studies, we selected four verbs for implementation in the priming study, each displaying different probabilities for the PO structure, arranged in increasing order of their bias. The verb *geben* ‘give’ was strongly biased towards the DO structure but allowed minimal alternation. The verb *bringen* ‘bring’ exhibited more flexibility towards the PO structure. *Verkaufen* ‘sell’ was also biased towards the DO, although not as strongly as the first two verbs. In contrast, *schicken* ‘send’ showed more bias towards the PO structure, particularly in adults. The average bias for all four verbs was approximately 20% towards the PO structure. This established bias provided a satisfactory balance for our research purposes. Since at least two of the verbs are used relatively frequently in the PO structure, we expected children to have some awareness of them. In order to make sure that children have some knowledge of the PO across all four verbs chosen for the study, we included a baseline in our priming experiment before the priming procedure. This served as a basis for gaining deeper insights into the structural preferences of the ditransitive targets in children and adults, and for examining whether children produce POs with all four verbs.

For the priming experiment, we created videos that depicted ditransitive actions, such as *Dora bringt Boots den Hasen* ‘Dora is bringing Boots the rabbit.’ These videos were accompanied by either DO or PO prime structures (*Dora bringt Boots den Hasen / den Hasen an Boots* ‘Dora is bringing Boots the rabbit / the rabbit to Boots’), which were presented interchangeably. The procedure was set up as a game in which the child and the experimenter took turns describing the videos. First, the experimenter described his video, serving as the prime. The child was instructed to repeat the exact sentence used by the experimenter to ensure that they paid close attention to the prime. Then, the child was asked to describe their own video in one sentence, mentioning all the characters and objects depicted. To assist the child, the experimenter always provided the beginning of the description: *Wendy gibt ...* ‘Wendy is giving ...’. The child then repeated the beginning of the sentence and completed the phrase. We deliberately chose a production-to-production paradigm rather than a comprehension-to-production approach. This approach ensured that the child was fully engaged with the prime and that the experimental procedure was similar to that used in two

studies with English-speaking children, as adapted from Rowland et al. (2012) and their follow-up study with Peter et al. (2015). To test for the lexical boost effect, we primed participants interchangeably, either with the same verb (SV) in prime and target or a different verb (DV) in prime and target. As previously reported, we also included a baseline in our priming study. In this baseline, all prime sentences featured intransitive actions, such as *Wendy springt* 'Wendy is jumping.' The targets, however, were always ditransitive actions. The baseline was designed to address several questions: 1) Will children produce ditransitive constructions, particularly the PO structure? 2) If so, what is the strength of the bias between the two alternatives? 3) Will priming increase the production of the PO structure after priming with POs compared to situations where children are not primed? To study cumulative priming effects, we entered trial numbers into our model, which counted whether the PO production would increase as a function of the increasing number of PO/DO tokens across the experimental procedure. All participants were exposed to these measures in four games in total, consisting of a practice session (game 1), a baseline pretest session (game 2), and one priming session, which was split into two halves with a break of 5 minutes to rest. Children between the ages of 3 and 6 had two testing points: the first testing point contained a practice and baseline session, and the second testing point contained the two experimental priming sessions. All children and adults, except for those aged 7 to 8 years, were also tested on three cognitive ability measures: verbal ability, non-verbal ability, and working memory. One of our complementary objectives was to examine potential relationships between priming effects and cognitive ability skills. As these measures did not provide meaningful insights into priming behavior, they are not reported in detail in the included papers. Nonetheless, verbal ability measures are reported in the paper on bilingual participants.

6.2 Theoretical relevance of the research

The results of this work were intended to provide further insights into a well-established priming account – The Implicit Learning Account - which is specifically dedicated to both developmental patterns of language acquisition and priming effects. The account is based on the assumption that non-predicted word sequences that we encounter from an incoming sentence result in an error signal. The stronger the error is (i.e., the more surprising the structure), the stronger our language system is biased towards the reproduction of a similar structure. Because the PO structure is generally rare in use in German and the results on the DA in German-speaking children suggested rather weak representation of the PO structure (due to little experience), we hypothesized that both children and adults would

show priming effects for the PO structure, that is, the PO production after a PO prime should be greater compared to a DO prime and compared to an intransitive prime (baseline). The change in frequency ratio is expected to lead to cumulative priming effects, meaning that the general PO production should increase when a structure is primed multiple times. Moreover, this account suggests that lexical boost effects arise because words that are shared between the prime and the target act as memory cues for the structure, resulting in greater activation of the structural representation. Consequently, lexical boost effects are thought to be linked to working memory. As a child's working memory resources improve with age, this account predicts a developmental trajectory for the lexical boost.

We also decided to test children who were raised bilingually in German and another language. We were primarily interested to investigate whether bilingually-raised children who are exposed less to German than their monolingual peers would also show abstract priming effects and have a sense for the structural bias of the language from early on. Research on this group of children contributes significantly to the literature, as research on the development of abstract structural representations in bilingual children remains relatively limited. While a few studies (Unsworth, 2023; Wolleb, 2015; Wolleb et al., 2018) have identified evidence of abstract within-language priming in bilingual children, studies of priming with bilingual children have mainly focused on cross-linguistic priming. Importantly, there is very little research on additional core priming effects, such as the lexical boost effect and cumulative priming as well as a lack of developmental approaches in this area. Specifically, it remains unclear whether bilingual children aged 3 to 4 years possess abstract representations of syntactic structures and how these representations are shaped throughout development compared to monolinguals. There is also no clarity about the extent to which cross-linguistic influence from the L1 affects structural choices in bilinguals and whether the extent to which they prime depends on the structural options available in their L1. To address these questions we gathered data on the structural options each background language allows and implemented structural influence as an additional predictor in our models. However, according to research on bilingual adults, the structural choices made in L2 production are not significantly affected by the distributional patterns of the structural realizations of the L1 for the structures being examined (Flett et al., 2013; McDonough, 2006). Therefore, we hypothesized that our bilingual children, as either simultaneous or early successive bilinguals, should demonstrate rather native-like processing in German although they might still exhibit subtle differences.

6.2.1 Initial representations

The results of the priming experiments involving monolingually and bilingually raised children revealed very similar patterns. During the baseline phase, we observed a clear DO bias in both groups. However, bilingual children produced more POs overall compared to monolinguals, while still remaining sensitive to the DO bias of German. Further analyses that included both bilingual and monolingual data showed an interaction between general PO production and language group (bilinguals vs. monolinguals), indicating that bilingual speakers generally preferred POs slightly more than their monolingual peers. Nonetheless, neither immediate nor cumulative priming effects were influenced by the language group. There is substantial evidence that bilingual speakers in general tend to prefer the PO structure over the DO structure (McDonough, 2006; Kaan & Chun, 2018; Shin & Christianson, 2009). Research on children has shown that even monolingual English-speaking children (e.g., Conwell & Demuth, 2007; Stephens, 2010) and monolingual Norwegian-speaking children (Anderssen et al., 2012) generally prefer POs over DOs. Anderssen et al. (2012) suggest that children tend to avoid syntactic movement and stick to the underlying form. While in DO structures the two objects appear after the verb without a preposition (e.g., *The teacher gave the boy the cat*), PO structures favor a preposition which serves as an explicit marker (e.g. *The teacher gave the cat to the boy*). This marker reduces ambiguity and the need for syntactic reordering which is less demanding for a child's developing brain. Hence, children find the PO easier to produce and comprehend. Importantly, Wolleb et al. (2018) speculate that bilingual children may omit syntactic movement even more frequently than monolingual children. Our developmental findings indicate that the preference for POs over DOs in bilinguals increases with age, continuing to grow into adulthood, and is not simply a result of early developmental stages. Interestingly, we observed a similar pattern in the monolingual children, suggesting increasing use of POs across age in our three child groups at baseline, with a slight drop in the adults which was different from the bilingual adults. Further, the strongest DO bias was observed in the youngest monolingual group (90%) and decreased in the 5- to 6-year-olds and the 7- to 8-year-olds (around 20-32% respectively). This suggests that the PO alternative in the youngest group is less firmly established compared to the older groups, possibly due to less exposure. This aligns with our results from the corpus analysis in CHILDES, where we found the first but highly limited instances of PO use around age four. In contrast, bilingual children aged 3 to 4 years did not show such a strong DO bias. However, both 3- to 4-year-olds and the 5- to 6-year-olds showed substantially more

sensitivity to the DO bias (around 80-76%) compared to the older age groups (around 59-56%).

Furthermore, the Implicit Learning Account predicts that our processor is influenced by statistical input throughout our whole life and should learn structural input most effectively in childhood; that is, children strengthen structural input with increasing exposure. Assuming that children start out with weak structural representations, we would expect that our data would show an overall increasing rate of PO production with growing age irrespective of prime condition. We observed this developmental trajectory with a growing numerical trend for general PO production in all child groups and a drop in the monolingual adults but not in the bilingual adults. This trajectory was numerically larger in the bilingual sample. We assume that the final drop of PO production represents its final representational establishment in the adults, because the weight system is not as susceptible to changes compared to children. For future studies, it would be interesting at this point to include a 9- to 10-year-old group in order to see whether they would still show a linear growing trend or a gradual decrease towards the direction of the adult group.

6.2.2 Abstract priming

We found significant abstract priming effects across all age groups in both monolingual and bilingual children and adults, except for the youngest bilingual children, who showed a numerical but non-significant trend towards priming. Recall that we hypothesized priming effects only if the children possess abstract representations for the DO and PO structure. While we found evidence for the existence of such representations in all child groups, the abstract representations of the youngest bilingual children seem to still be developing. However, we would also like to point out that the numerical priming effect, as well as the beta value in the model for the 3- to 4-year-olds, was very similar to that for the 5- to 6-year-olds bilingual children. Hence, due to a smaller number and noisier data from bilingual children compared to monolingual children, the non-significant result may have resulted from insufficient statistical power.

We also observed an interesting result in the 3- to 4-year-old monolingual children: their abstract priming effect in the different verb (DV) condition was significantly stronger than that of the older age groups. Specifically, while the other three age groups showed a numerical trend toward a lexical boost effect, with stronger priming in the same verb (SV) condition compared to the DV condition, the 3- to 4-year-olds showed a stronger abstract priming effect in the DV condition which was supported by a three-way interaction. Previous

studies have also reported a stronger tendency of priming effects in children compared to adults (Kumarage et al., 2022; Messenger et al., 2011a; Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018), although these effects have typically not reached statistical significance. Our present findings are consistent with the predictions of the Implicit Learning Model, which suggests that younger children experience larger priming effects due to increased surprisal. This is because young children have encountered the rarer structure (in our study, the PO structure) much less frequently than older age groups, leading to less efficient predictive abilities. As a result, they are more likely to experience prediction errors, which may explain the stronger priming effect observed in this age group. The same holds for bilingual children with the only difference that if they had the same initial DO bias as the monolinguals, they would have probably shown the same pattern. In fact, the baseline results showing the least production for the PO structure among the youngest monolingual children further support the notion that their predictive mechanisms are still developing, and this increased prediction error can be interpreted as a genuine surprisal effect. Our results thus support the early abstraction account at least for the monolingual children, suggesting the possession of early abstract representations starting from the age of 3 years. With respect to the bilingual children, we also find early abstraction, but more clearly starting from age 5 to 6 years, supporting rather the early lexicalist account in the youngest bilingual group. However, given that the descriptive patterns and slopes in the model for the 3- to 4-year-olds closely resemble those of the older children, we believe the lack of sufficient statistical power in this age group—due to its variability and smaller participant size—limits the strength of the claim in support of the lexicalist view.

6.2.3 Lexical boost effect

The results regarding the development of the lexical boost effect were consistent across both monolingual and bilingual children. As predicted by the Implicit Learning Account, this effect emerged gradually over development, becoming most pronounced in adults, who exhibited a substantial lexical boost. According to the Implicit Learning Account, the lexical boost effect arises from a distinct mechanism—working memory. The Implicit Learning Account suggests that when a content word appears in both the prime and target, it serves as a memory cue for the prime, which biases the speaker to reproduce this structure. In support of this, Scheepers et al. (2017) observed lexical boost effects not only for prime-target pairs sharing the head verb, but also for those with shared non-head constituents. If this is indeed the case, then both bilingual and monolingual children should rely on the same

underlying mechanism, as it is independent of linguistic proficiency. Since there is no published work on the lexical boost within a single language for bilingual children, our results align best with the study by Kumarage et al. (2022). The authors examined active and passive priming in English monolingual children and observed the development of the lexical boost effect across increasing age, but emerging earlier compared to findings in our study (at 48 and 54 months). Children in this study were tested at four testing points longitudinally through age five. These differing outcomes underscore the importance of conducting further studies with developmental approaches, as effects may vary with age depending on the structure, language, and possibly the methodology employed. Further, if the lexical boost effect is indeed linked to working memory as proposed by Chang et al. (2006), its emergence should depend on the developmental stage of working memory in children, the linguistic phenomenon under investigation, the language and possibly the experimental task. Although all the work in children revealed important insights into the syntactic processing when lexical items were shared (Branigan & McLean, 2016; Branigan et al., 2004; Foltz et al., 2015; Gerard & Keller, 2010; Morris & Scheepers, 2015; Peter et al., 2015; Rowland et al., 2012; Savage et al., 2003; Thothathiri & Snedeker, 2008) the diverging results do not allow to draw strong conclusions. Our work provides important support for a developmental trajectory extending beyond the age ranges most commonly studied and encourages future research to include even older children, possibly between ages 7 and 12 years, to determine when children catch up with adult processing and exhibit similarly strong lexical boost effects.

6.2.4 Surprisal effects

We observed priming effects for the PO structure across all age groups in both monolingual and bilingual participants. By including a baseline measure, we found that the PO production was relatively low during the pre-test. However, when participants were primed, there was a noticeable increase in their overall PO production compared to when they were not primed, confirming the influence of priming. Given that German is heavily biased towards the DO structure, we surmise that surprisal effects were evident across all groups. However, the most pronounced surprisal effect was observed specifically in the 3- to 4-year-old monolinguals, who exhibited a DO preference of 90% in the baseline, the highest among all groups, and showed a significant, almost twice as high PO production after priming compared to all other groups (see Section 6.2.2 for details).

6.2.5 Cumulative priming

Further, we found an increase in PO production across the entire experimental session in all participants except for the monolingual adults regardless of the type of prime used. This suggests that as both bilingual and monolingual groups were exposed to alternating PO or DO structures during the session, their PO production gradually increased while DO production decreased. These findings align with the Implicit Learning Model, which posits that our cognitive processing system adapts to structures with increasing exposure. Every time an error is encountered, there is a slight adjustment in the weighting system that influences the likelihood of producing the primed structure. Consequently, with more instances of these structures, individuals tend to adapt over time, leading to incremental production patterns that stem from long-term priming effects rather than immediate priming effects. This implies that our internal representations are continually updated throughout our lives, indicating a dynamic language system that is always open to change based on probabilistic patterns. Hence, long-term adaptation should be more pronounced in younger children and decrease with growing age. In line with this theory, our analyses revealed that the youngest children were most susceptible to cumulative priming effects, and this effect decreased as children became older. Our results for the bilingual children contrast with those of Unsworth (2023) who found a decrease in priming effects in bilingual children with increasing trial number. We did not find significant effects of cumulative priming in the monolingual adults; however, the bilingual adults did show a significant effect (in contrast to Jeager 2008; 2013), consistent with the findings in the priming literature for bilingual adults (Kaan and Chun, 2018; Kaschak and Borreggine, 2008; Kaschak et al., 2006; Kaschak et al., 2011). This finding may be also explained by the Implicit Learning Account. Since bilingual adults' language representations may be less developed and weaker than those of monolinguals, they may be more influenced by priming than monolinguals, whose language representations are more stable and resistant to change in adulthood. Further, in line with most research on cumulative priming effects, we find cumulative effects across all groups only for the rarer structural alternative, but not for the frequently-used option (in line with Fine et al., 2013; Jaeger, 2016; Jaeger & Snider, 2008, 2013; Kaan & Chun, 2018; Kaschak et al., 2011, 2014; Reitter et al., 2011). We did not find immediate priming effects in the youngest bilingual children, but we did find cumulative priming effects. For every less frequent structure encountered, the production across the experimental procedure for that structure increased. Although we interpreted the non-significant priming effects in the youngest children as an absence of abstract representations for this structure, we still observed how this construction developed and was strengthened with each prime exposure. When participants expect a frequent prime but are presented with a

less frequently-used prime instead (in our case, a structure that might not be yet fully established in their representations), they perceive the mismatch as an error signal, indicating a discrepancy between their expectations and the actual input. While their representations are not strong enough to immediately activate or build up the rare structure in the target sentence, the priming effect is still significant enough to build up over time - that is, across the experimental procedure - leading to cumulative priming effects. This suggests that while the initial activation may not be sufficient for an immediate response, it accumulates and influences subsequent responses, which is in line with the predictions of the Implicit Learning Model (Chang et al., 2006) that syntactic learning and priming can be gradual in nature.

6.2.6 L1 influence on L2 priming

Our results revealed no clear influence of the structural realizations in the L1s (background language) of our participants on the priming behavior in the L2 (German). These results provide evidence for the view that structural preferences are language-specific, with experiences in one language affecting syntactic choices primarily within that same language. These findings align with research in bilingual adults showing that the L2 is not affected by either the distributional or the linguistic properties of the L1 at high proficiency levels (Flett et al., 2013; Kim & McDonough, 2008, 2016; McDonough, 2006; Ruf, 2011; Schoonbaert et al., 2007; Shin & Christianson, 2012), and that any cross-linguistic influence during priming is rather weak or absent. Our results are consistent with Flett et al. (2013), who questioned whether bilingual speakers' processing of their non-native language (L2) is influenced by their native language (L1). The authors found that L1 English and advanced L2 English speakers with either Spanish or German as the L1 showed the same structural priming for PO and DO dative constructions. Crucially, the Spanish speakers had no DO construction in their L1 and the PO in German speakers is relatively rare, yet they showed no difference in priming magnitude in English. Similar to the L1 backgrounds in our study, McDonough (2006) demonstrated no difference in priming among L2 speakers from various L1 backgrounds. However, her results also suggested that priming effects are only possible if L2 speakers have fully acquired an abstract representation of the relevant structure (see also Kaan & Chun, 2018; Shin & Christianson, 2012). Since we found both abstract and cumulative priming effects in the bilinguals, except for abstract priming effects in the youngest age group, all these groups must have acquired an abstract representation for the primed structures. One difference that was found for the bilinguals compared to monolingual speakers is the generally weaker DO bias, irrespective of priming. However, all bilinguals still showed a

clear sensitivity for the structural bias of the target language and did not show differences in priming magnitude. Importantly, a bias towards the PO structure that is somewhat greater than observed in monolinguals was demonstrated in several priming studies in L2 speakers and has been interpreted as cognitively less complex and more explicit in marking relationships between verbs and their arguments (Chang et al., 2003; Hartsuiker et al., 2004; McDonough, 2006). As noted in section 6.2.1, the PO construction has also been experienced as less ambiguous and cognitively easier to process in monolingual children, which led to speculations that bilingual children might benefit from this structural alternative even more.

With respect to child priming research, our results align with those of Wolleb et al. (2015) and Unsworth (2023), who found no significant difference in priming behavior between bilingual children and monolingual controls within the target language. Specifically, Unsworth (2023) found no evidence of structural preferences in the heritage language influencing priming behavior in the target language. Minor effects were observed only when the heritage language lacked an alternative structural form. These results mirror Genesee's (2008) observations that bilingual children develop two interconnected language systems with abstract representations for structures, which can influence each other during early stages of development. With growing age, the two systems improve and the children gain more control to effectively manage and activate one language over the other. Their abstract cognitive control mechanism allows them to juggle both language systems in a more monolingual-like behavior (Genesee et al., 1995). Our findings regarding the impact of structural alternatives in a child's background language align with Genesee's observations. They suggest that there is little to no interference throughout development, likely due to early bilingual acquisition and a relatively high level of proficiency, resulting in a language system that is more alike to that of a monolingual. According to the standardized receptive grammar assessment (TROG), the bilingual children in our study demonstrated strong receptive grammar skills and therefore may have shown rather native-like priming behavior. Similar patterns have also been observed in studies on cross-linguistic influence in early bilingual children. For instance, in a meta-analysis of 26 experimental studies involving simultaneous and successive bilingual children, van Dijk et al. (2021) found influence at the morpho-syntactic level between languages. However, the effects were generally weak, suggesting a relatively similar performance to monolingual children. Notably, the authors reported stronger influence from the societal language to the non-societal language, a pattern that does not appear in our sample. Other work agrees that children go through different developmental stages and show many differences in their language abilities on an individual level and it is therefore very

challenging to determine transfer effects, especially in predicted directions (Foroodi-Nejad & Paradis, 2009; Nicoladis, 2002, 2003, 2006; Paradis, 2023).

6.3 Conclusion and outlook

The present dissertation has aimed to fill several gaps in the structural priming literature specifically in children, by taking a developmental approach which allowed us to study structural priming behaviour across several stages of language development (ages 3-4, 5-6, 7-8, and adults). Most existing research on structural priming in children has focused on much narrower age ranges and importantly, may have missed finding effects that emerge either earlier or later in development. Our main task was to track core priming effects – *abstract priming, lexical boost effect, surprisal* and *cumulative priming* – that are traditionally observed in adult literature. In particular, the lexical boost, surprisal and cumulative priming are not sufficiently researched in monolingual children and research is extremely limited with respect to bilingual children. Therefore, a key contribution of this work is its focus on bilingual children, a relatively underexplored group in priming research.

Another major contribution of this work lies in a language other than English, which has already been extensively studied in child priming research. German differs substantially from English in that the prepositional object structure (PO) is very uncommon in use compared to its alternative, the double object structure (DO). This raised the key question of whether children have fully acquired the abstract representation for the rare PO structure, in particular at the youngest stages of development. This question was grounded on our preliminary research in the CHILDES database, which revealed very little to no use of POs in child speech and very rare occurrences in child-directed speech. Together with a sentence completion task (elicited production) and a grammaticality judgment task designed for adults, we still observed a very strong bias towards the DO with little PO use for particular verbs. Crucially, we observed that even in a strongly DO-biased language, verbs showed substantial variability in their PO biases, although they generally remained DO-biased. Furthermore, we found evidence that verbs previously documented as not alternating were in fact produced by both children (e.g., *geben* ‘give’) and adults (e.g., *geben* ‘give’, and *reichen* ‘hand’) and judged as fully grammatical. One verb (*schicken* ‘send’) was even found to be PO biased (60%). All these results from our pre-studies established the basis for the design of the priming study and our hypotheses about the priming behaviour across development.

Our findings answer the question that even young monolingual children show abstract and cumulative priming effects for rare structures like the German prepositional object (PO)

and must possess an abstract representation for it, despite its low frequency in the input and the limited exposure of this construction. In contrast to most previous studies that report only numerical trends of greater priming magnitude for children compared to adults (Peter et al., 2015; Rowland et al., 2012; Thothathiri & Snedeker, 2008b; Wolleb et al., 2018), we found a robust increased priming effect in the youngest children—approximately twice as large as that observed in older children and adults. This shows a genuine surprisal effect in younger children, likely due to stronger DO bias and therefore stronger prediction error, which may be linked to cross-language differences in structural frequencies. Further, these results suggest that younger children are still acquiring the structural frequencies available in their language and have overall weaker representations for the PO structure compared to their older peers. However, by ages 5 to 6, children appear to catch up with older peers, showing comparable patterns. By comparing bilingual and monolingual children, we further show that bilinguals (who are exposed to German substantially less frequently than monolinguals) still demonstrate abstract syntactic priming and a clear sensitivity to the language's structural biases from an early age. Although we do not find a significant abstract priming effect in the youngest bilingual groups, the presence of cumulative effects clearly shows how their representations can be reshaped during exposure, leading to an enhanced formation of abstract representations within a short period. Together, our findings in bilinguals challenge assumptions that reduced exposure may delay or diminish abstract syntactic representation over development.

Moreover, our inclusion of structural properties of participants' first languages as predictors reveals that, consistent with adult bilingual priming studies and many studies on language transfer effects in children, cross-linguistic influence during syntactic priming within a language is minor, supporting the view that structural preferences are largely language-specific. The minor influence that we observed was a slightly stronger bias toward the PO structure, which aligns with previous studies demonstrating a general PO preference among less proficient speakers, such as early bilinguals, late L2 speakers and young monolingual children (who frequently use PO and DO structures). This finding supports the view that bilinguals employ processing strategies to reduce structural complexities.

The most important contribution to the priming field is the discovery that monolingual and bilingual children follow the same developmental trajectory with respect to the lexical boost effect. Research on this effect was limited and inconsistent in the monolingual priming literature, and, to date, no published studies have examined it in bilingual children. Our results provide evidence that similar cognitive mechanisms involved in prime-target

processing are at work in both groups. It is worth mentioning that although our results for monolingual children are in line with those of Kumarage et al. (2022), who also showed a developmental trajectory in monolingual English children for passive structures, they differ in terms of the timing of the lexical boost effect. While Kumarage et al. (2022) observed the emergence of this effect around 4;0 to 4;5 years, our children showed the lexical boost effect emerging much later, around 7 to 8 years of age. Notably, this later emergence was anticipated based on observations from Rowland et al. (2012) and Peter et al. (2015), who reported a numerical trend toward a lexical boost effect in 5- to 6-year-old English-speaking children. These findings suggest that the cognitive mechanisms underlying the lexical boost effect may be universal and not language-specific. In other words, despite cross-linguistic differences in structural frequencies, the processes responsible for increased priming effects through lexical overlap appear to operate similarly across languages, at least for datives. However, given that some studies report this effect at earlier stages, and considering the ongoing debate surrounding the existence of the lexical boost effect, the precise age at which it emerges and varying priming methodologies, further research is necessary.

We also contributed to the literature by providing a more global understanding of cumulative priming effects through a developmental approach, addressing the limited and inconsistent research on this effect in children. Notably, the developmental trajectory follows a similar pattern in both monolinguals and bilinguals: all groups exhibit cumulative effects that are most pronounced in the youngest children and gradually decrease with age, disappearing completely in monolingual adults.

Importantly, all our findings align best with the Implicit Learning Account, which offers a unified explanation in both the monolingual and the bilingual samples. The account has not been widely applied to bilingual child processing within a single language, and we provide evidence that the same underlying mechanisms are engaged in this population. The main value of this account lies in its consideration of structural frequencies and posits that unexpected syntactic structures lead to prediction error, which biases our internal representations towards immediate reproduction of that structure. Hence, exposure to the surprising structure incrementally shifts our internal representations towards the rarer variant across time, suggesting that we continue to learn and adapt to incoming structures throughout the lifespan. Such adaptation and learning processes are considered to be most pronounced in young children and decrease with age due to more language experience and less learning demands. Consequently, this theory can explain abstract (lexically independent) priming effects, surprisal and cumulative priming effects from a developmental perspective.

Moreover, the developmental trajectory of the lexical boost effect aligns with improvements in working memory, highlighting the interaction between cognitive development and syntactic processing. Neither the Residual Activation Account (Pickering & Branigan, 1998) nor the ACT-R Model (Reitter et al., 2011) can explain the absence of a lexical boost effect in children and its developmental trajectory. Both models similarly account for the lexical boost effect by attributing it to temporary activation, either through lemmas and combinatorial syntactic nodes (Residual Activation Account) or through memory retrieval cues (ACT-R model). Crucially, both models predict increased priming when there is lexical overlap between the prime and the target (see Section 2.3.4 for more detail). In addition, The Residual Activation Account has difficulty accounting for structural biases and long-term or cumulative priming effects, because it generally assumes a rather short activation of a primed structure, regardless of the lexical overlap. As a result, both lexically dependent and lexically independent priming effects are predicted to diminish quickly. For these reasons, The Implicit Learning Model proved to deepen our understanding of how children acquire and process syntactic structures in a structurally biased language and pave the way for future studies to explore how implicit learning mechanisms shape bilingual language development.

Looking ahead, future studies should adopt a developmental perspective to avoid mistakenly interpreting null results as evidence for the absence of an effect. Such effects may simply be present in slightly younger or older children and thus go undetected within narrow age ranges. To address this, we strongly recommend expanding the age range typically studied and include older children and adolescents. This broader approach would help identify when internal mechanisms begin to align with those observed in adults. Importantly, to draw reliable conclusions about developmental trajectories, studies must include appropriate baseline measures and carefully consider structural and processing differences between child and adult populations.

Overall, this thesis extends the theoretical reach of the Implicit Learning Account by providing new developmental and bilingual evidence for its assumptions, offering a unified model of language acquisition for a monolingual and bilingual mind, and highlights the interaction between input frequency across different languages, learning mechanisms, and developmental timing.

6.4 Frame text references

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6.5 Attachments

Appendix A: Overview of corpora, recording periods, age ranges, and participant backgrounds

Corpora information	Child's name	Special information	Recordings	Analyzed files of child speech	Analyzed files of child directed speech	Father	Mother	Sibl-ings	Notes
University of Heidelberg; created by Christiane von Stutterheim 1988; longitudinal study. Von Stutterheim, Christiane (1988). CHILDES Database German von Stutterheim Corpus. Doi:10.21415/T5NS5S	Caroline	-	240 recordings. 0;10-4;3 on a regular basis; from 0;10 until 1;08 2-6 days a month; from 1;09 till 2;10 10-16 days a month; between 3;03 and 4;03 recorded 3 days a month	All available files. 89-10-10.cha starting with age 2;0 until 91.01.31.ch ending with age 4;3	All available files. 89-04-02.cha starting with age 1;6 until 90-08-22.cha ending with age 2;10	-	-	-	There is almost no data on the 230ecording from age 2;10 – 4;03.
A monolingual German boy, grew up Leipzig, Germany. The Leo-corpus was collected in Leipzig, Germany by the Max-Planck-Institute for Evolutionary Anthropology by Heike Behrens 2010. Longitudinal study. Behrens, H. (2006). The input-output relationship in first language acquisition. Language and Cognitive Processes, 21, 2-24.	Leo	All filenames start with "le" for LEO and 6 digits representing his age in YYMMDD. Thus, le020314.ch stand for Leo age 2;3 and 14. Days. At age 2;10, he started to go to child care. Leo is a late talker and his vocabulary is relatively large before grammatical development sets in. But Leo turned out to be a very quick learner, acquiring sophisticated vocabulary and morphosyntax rather rapidly.	501 recordings between age 1;11 and 4;11. At age 1;11 Leo was recorded for 9 days, from age 2;00 until age 2;11every day, from age 3;00 until age 4;11 5 days in a raw per month.	Le020003.chstarting with age 2;0 until 3;0 all recordings were analyzed. From age 4;0 – 4;11 2 recordings per month were analyzed.	Le011112.cha starting with age 1;6 until age 3;0 all recordings were analyzed. From 4;0 – 4;11 two recordings per month were analyzed.	Higher education; age 35	higher education; age 30	sister was born when Leo was 3;3	-
Between 1990 and 2003, Rosemarie Rigol, a former professor of German linguistics at the University of Osnabrueck, took more that 1900 30-minute recordings of children acquiring German as their first	Cosima	There are 129 recordings (tape or video) of Cosima's development between ages 0;00,13 and 7;2,22. Transcriptio	0;00-7;2; taken at regular intervals	cs010813 – cs070222; starting with age 1;8	cs010813 – cs070222; starting with age 1;8	university education; age 33	vocational training; age 34	brother: Niklas	During 230ecording several people are present: mother, brother, the child's

language. Two intelligence tests (German versions based on the Catell-Tests) were taken. The tests served to determine the range of intelligence measures and to ensure compatibility when analyzing the children's language development. Behrens, Heike (1990). CHILDES Database German Behrens Corpus. Doi:10.21415/T50S34		n started at age 1;8.22. Up to age 4, children were recorded for 30 minutes every two weeks, after that every 4th week.							friend Ina, and her cousins Kai and Markus.
	Sebastian	-	There are 134 recordings (tapes or videos) between ages 0;00,17 and 7;5,11. Transcription started at age 2;1.12. Recordings were taken from regular intervals: from age 00;00 until 4;0 two times per month (30 min.) and from age 4;0 until 7;5 one time per month	Recordings were analyzed from sb020714.cha starting with age 2;7 until sb 070414. Cha ending with age 7;4.	Recordings are analyzed from sb020112.cha starting with age 2;1 until sb070511. Cha ending with age 7;5.	Vocational training	vocational training	younger brother Christian	Sebastian has a lot of contact with his grandparents
	Pauline	-	There are 130 recordings (tapes or videos) between ages 0;00,12 and 7;11,03. Transcription started at age 1;10.12. Recordings took place more or less at regular intervals: from age 0;00 until 4;0 twice per month (30 min), from age 4;0 until 7;5 once per month.	Recordings were analyzed from pa020005.cha starting with age 2;5 until pa070629.cha ending with age7;6.	Recordings were analyzed from pa011022 starting with age 1;10cha until pa 070727.ch ending with age 7;7.	University education	university education	older brother (3 years older) Robert	She has intensive contacts with her aunts and uncles as well as with 6 cousins. Because of the many activities and trips of Pauline and her parents, 231ecording couldn't take place at regular intervals.

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M.A. 2008-2009	English Philology and Literature
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Publications

Karkaletsou, F., **Kholodova, A.**, & Allen, S. E. M. (2024). Exploring bilingual adaptation to structural innovations: Evidence from Canadian French. *Languages, 9*(12), 375. https://doi.org/10.3390/languages9120375

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International Presentations

2025
Kholodova, A., Karkaletsou, F., & Allen, S. E. M. (June 2025). *Across-language abstract priming and the translation-equivalent boost in English-German-speaking children and adults* [Poster presentation]. 15th International Symposium in Bilingualism (ISB15), Donostia-San Sebastián, Spain.

2024
Kholodova, A., Karkaletsou, F., & Allen, S. E. M. (September 2024). *Investigation of core priming effects in monolingual and bilingual children: A developmental approach* [Poster presentation]. 30th Architectures and Mechanisms of Language Processing Conference (AMLaP), Edinburgh, Scotland.

Kholodova, A., Karkaletsou, F., & Allen, S. E. M. (July 2024). *Within and across-language priming trajectories across development in a structurally biased language* [Conference talk]. XVI International Congress for the Study of Child Language (IASCL), Prague, Czech Republic.

Kholodova, A., Karkaletsou, F., & Allen, S. E. M. (May 2024). *Within and across-language priming and the lexical boost across development in a structurally biased language* [Poster presentation]. 5th Symposium on Bilingual and L2 Processing in Adults and Children (ISBPAC), Swansea University, UK.

2023

Karkaletsou, F., Kholodova, A., & Allen, S. E. M. (August 2023). *Exploring bilingual adaptation to syntactic innovations: Evidence from Canadian French* [Poster presentation]. Summer School of Linguistics (SSoL 23), České Budějovice, Czech Republic.

Kholodova, A., Karkaletsou, F., & Allen, S. E. M. (June 2023). *Priming effects based on prediction error across development* [Poster presentation]. LingCologne2023: Prediction in Language, Cologne, Germany.

Karkaletsou, F., Kholodova, A., & Allen, S. E. M. (May 2023). *Exploring cross-linguistic influence and adaptation to innovations: A rating study with bilinguals in Canada* [Poster presentation]. Psycholinguistics in Flanders (PiF), Ghent, Belgium.

2022

Kholodova, A., Peter, M., Rowland, C., & Allen, S. E. M. (August 2022). *Cumulative priming effects across development in monolingual and bilingual children* [Conference talk]. 4th International Symposium on Bilingual and L2 Processing in Adults and Children (ISBPAC), Tromsø, Norway.

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2019

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